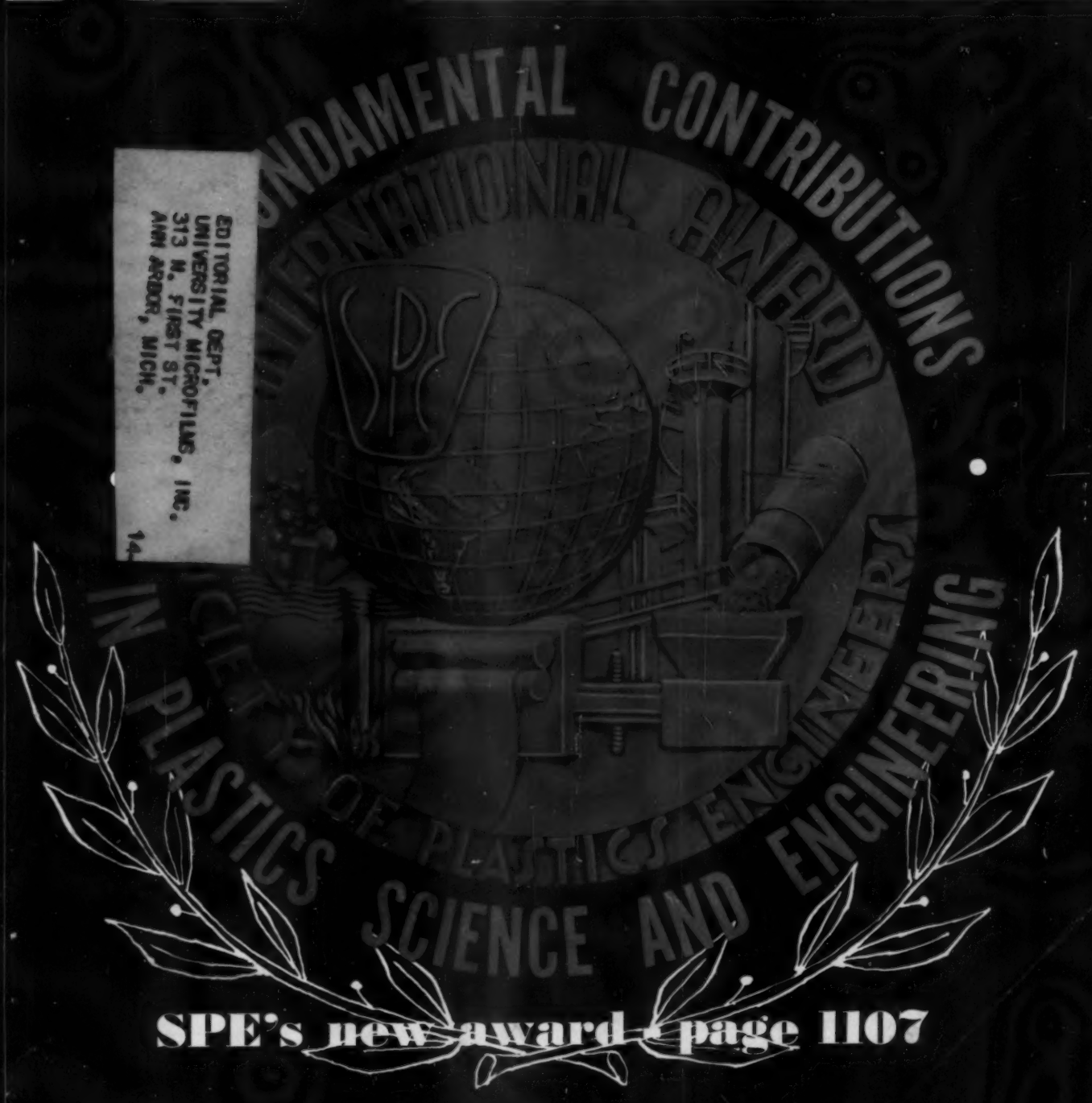
VOL. 17, NO. 10 • OCTOBER 1961

SPE JOURNAL

The Official Publication of the Society of Plastics Engineers, Inc.



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SPE's new award - page 1107

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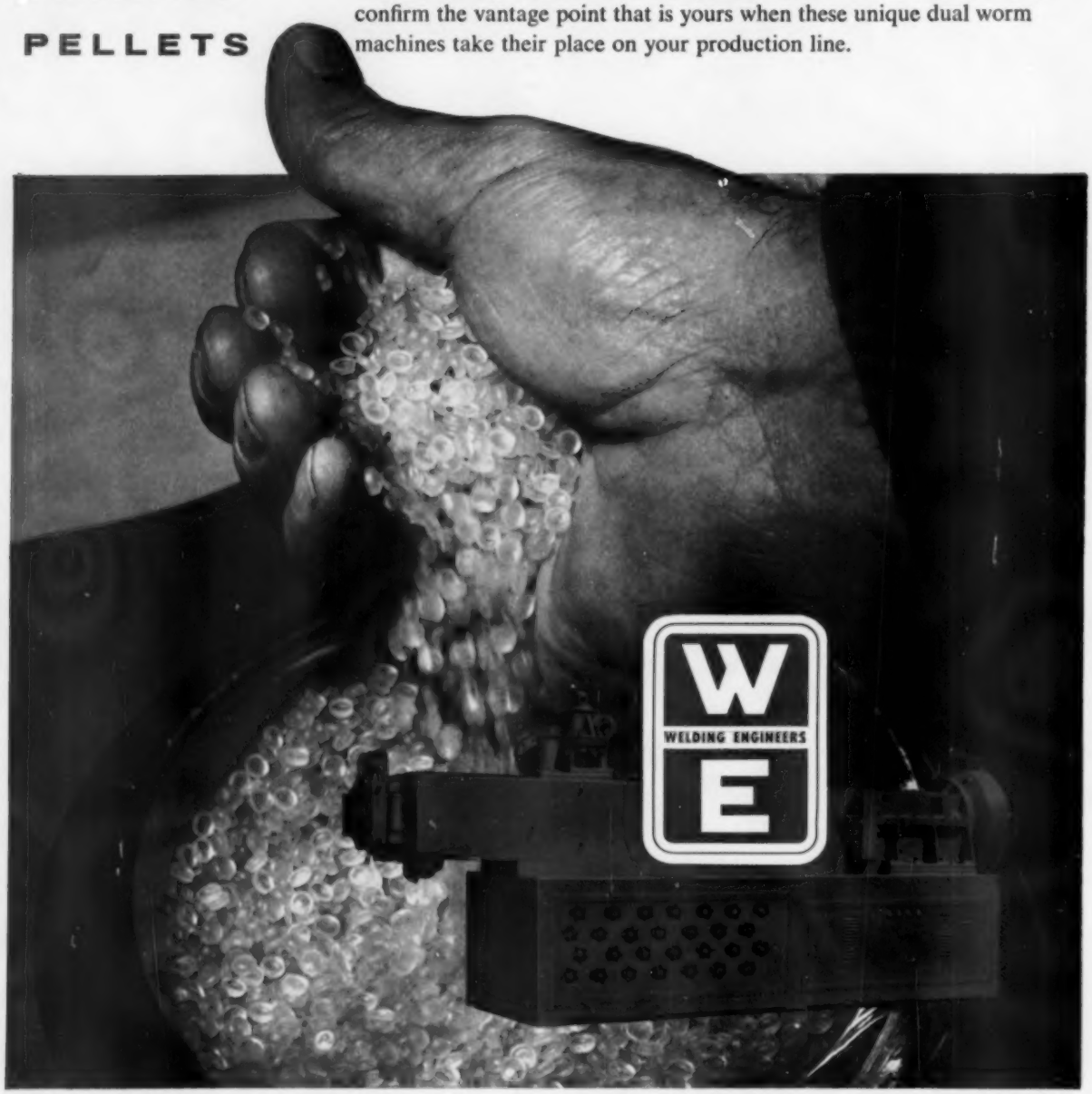

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Hughes 269A compact, low-cost helicopter, designed and mass-produced by Hughes Tool Co., Aircraft Division, Culver City, California, utilizes extrusions of rigid Geon manufactured by Ryko Products, Inc., Los Angeles. Portions of Geon extrusions are shown inset: ① aerodynamic shape is part of slat across cabin top; ② flat, notched sections contain and seal plastic canopy; ③ T-shaped section is part of tail boom spoiler. B.F. Goodrich Chemical Company supplies the rigid Geon vinyl resin.

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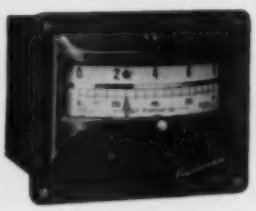

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SPE JOURNAL
VOL. 17 NO. 10
OCTOBER 1961

COVER:
SPE medal to be presented to the outstanding international plastics engineer

SPE Journal Newsletter 1049

REGIONAL TECHNICAL CONFERENCES

Vinyl Plastics in the Household Nov. 15, 1961, sponsored by the New York Section
Applications and technology of vinyls 1057

Plastics in Packaging Nov. 2-3, sponsored by the North Texas Section
Equipment, material and design developments 1116

Special Feature

Reclamation of Thermoplastics
Louis I. Naturman, Technical Editor, SPE Journal
Markets, processes and industry structure reviewed 1059

SPE Journal Features

Speaking of Extrusion—Ram Accumulators for Blow Molding
C. J. Waechter and A. W. Pomper, Waldron-Hartig Div., Midland-Ross Corp.
Advantages, limitations and design requirements of accumulators in blow molding 1065

Reinforced Plastics—Laminating Techniques and Laminate Compositions
S. S. Feuer and A. F. Torres, Atlas Chemical Industries Inc.
Correct material choice and proper fabrication techniques for good corrosion resistance 1071

Molding Cycles—Encapsulation Through Molding
Milton A. Sanders, Precision Molding Inc.
A new field for the injection molder—molds for encapsulation 1079

Technical Articles

Properties of a New Polyester Film
M. T. Watson, Tennessee Eastman Co.
New film is more stable in severe environments, and has good dielectric properties 1083

A Study of Maleate and Fumarate Polyester Resins
Robert E. Park, Ruth M. Johnston, Arthur D. Jesensky, Robert D. Cather. Pittsburgh Plate Glass Co.
Behaviour of polyester resins as a function of maleate-furmarate concentration ratio 1088

Diallyl Phthalate Monomer
Gene Nowlin and L. S. Burnett, FMC Corp.
Properties, reactions and applications of DAP discussed 1093

Plastic Flow in Injection Molds
F. J. Rielly and W. L. Price, Celanese Polymer Co.
Method for tracing plastic flow used to improve molding conditions 1097

Some Blue Sky Packaging Ideas
Ralph H. Hansen, Monsanto Chemical Co.
Highly imaginative packaging methods can be practical 1102

News of SPE

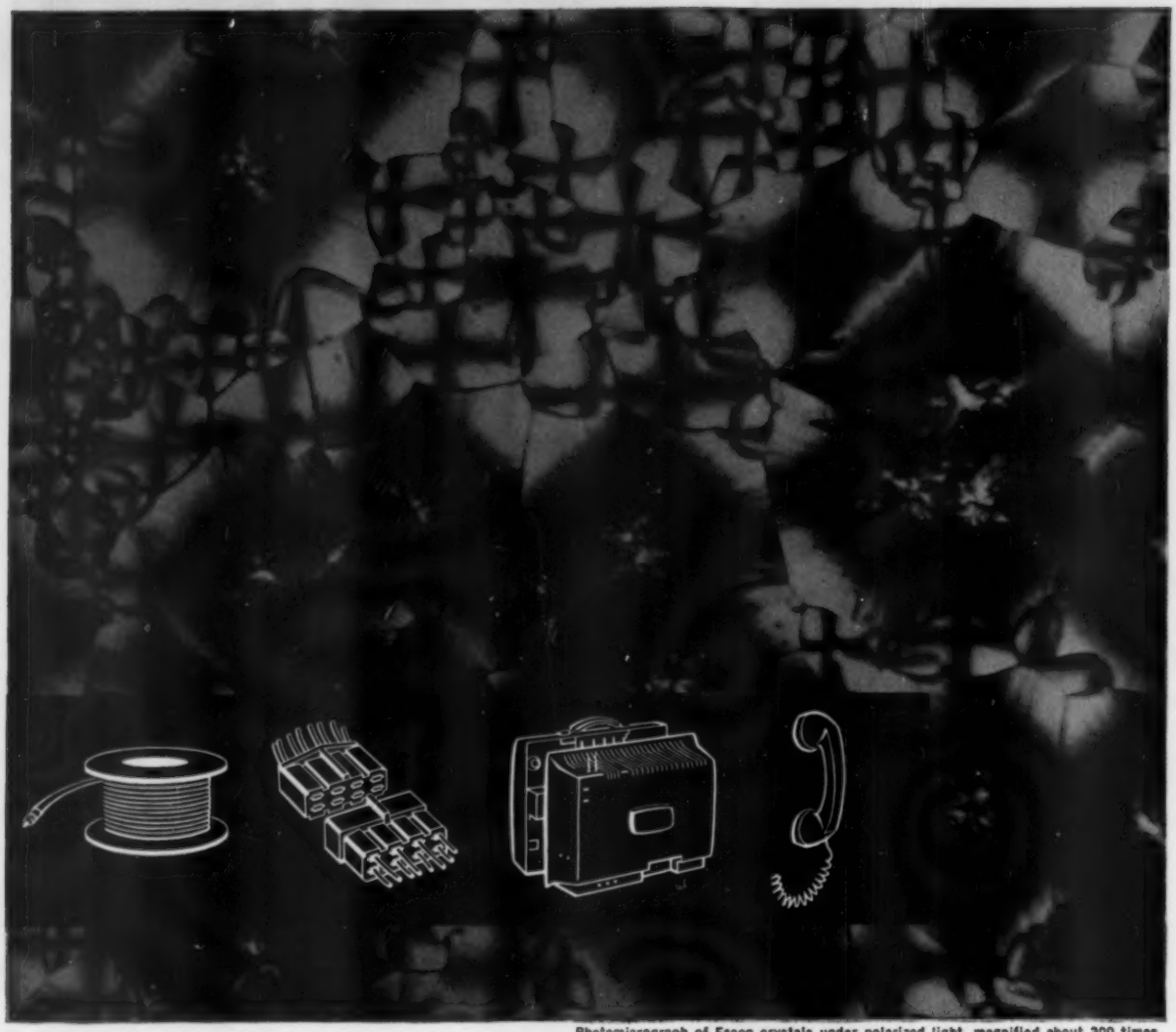
Society Action—New Award to Honor Outstanding International Plastics Engineer
Frederick C. Sutro, Jr. Chairman, Past Presidents Advisory Board (Cabot Corp.) 1107

PAG Progress—Newest PAG to Develop and Coordinate Plastics Color Technology
Laurence R. Sherman, Vice-chairman, Coloring of Plastics PAG (Imperial Color Chemical & Paper) 1110

Departments

Editorial 1041
Letters to the Editor 1045
Plastics Around the World 1115
Technical Meetings Calendar 1116
Book Reviews 1118
About Members 1120
New Equipment and Materials 1123
Employment and Service Guide 1127
Advertisers' Index 1132

What's News in Plastics...



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Vicat softening point (1 kg), °F	266-293
volume resistivity, ohm-cm	6.5×10^{16}
dielectric strength, volts/mil	
short time, ⅛" thickness	660
step-by-step, ⅛" thickness	650
dielectric constant, 10° cycles	2.0
dissipation factor, 10° cycles	0.0002-0.0003

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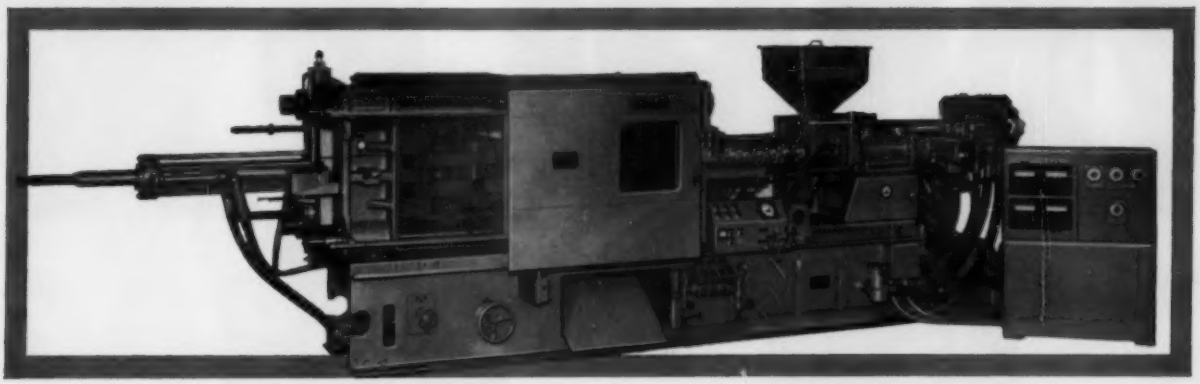

Condensed Screw Specifications				
	275TC	**350TC**	**350TCL**	**450TC**
Material injected per shot (cu. in.)	57.5	57.5	57.5	57.5
Material plasticizing capacity (lbs./hr.)	200	200	200	200
Material displacement rate (cu. in./min.)	1138 (30HP)	1510 (40HP)	1510 (40HP)	1771 (50HP)
	1150 (40HP)	1770 (50HP)	1770 (50HP)	
Screw diameter (in.)	3⅞	3⅞	3⅞	3⅞
Plunger speed forward (in.)	130 (30HP)	172.5 (40HP)	172.5 (40HP)	220 (50HP)
	172.5 (40HP)	220 (50HP)	220 (50HP)	
Mold clamping pressure (tons)	275	356	372	480
Mold clamping stroke, in. (adjustable)	6¼—11½	7½—14½	8½—20¼	6—22⅝
Platen size, in. (H x V)	27x27¼	32½x32½	32½x32½	40x40
Space between tie bars (H x V)	16½x16½	20½x20½	20½x20½	26x26
Motor HP	Std.—30	Std.—40	Std.—40	50
	Optn'l-40	Optn'l-50	Optn'l-50	

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EDITORIAL

Some Research Parameters

The plastics industry can probably point to the heavy emphasis placed on fundamentals in research work as the factor contributing most significantly to its past success. It is this tradition which will largely shape the plastics industry of the future.

There is, of course, tremendous activity in the field of polymers, both in the chemistry and engineering of new systems. Any one of a dozen basic research projects could in itself be the basis for a new branch of the plastics industry. This brief editorial takes an even briefer look at some of the present research parameters which we think are capable of exerting a strong vectorial influence on the present-day plastics industry.

Perhaps the area of investigation that appeals to the imagination more than any other area is the use of polymers as conductors and semi-conductors. There is now great activity in this field with much yet to be learned. It is known, for instance, that conjugated systems in polymers enhance electrical properties. But there are other factors just as important which at the present time defy isolation and subsequent correlation. The possibilities are staggering. For instance, synthetic, electronically active materials with preselected properties may be possible.

Another area of great promise in the plastics field is chemical crosslinking in polymers. There is much work being done in this area. Some practical benefits: a material that is thermo-plastic at processing temperatures, but once crosslinked, with simple salts for instance, a material that has all the physical properties of a thermoset plastic.

Finally, the work now progressing in making block and graft copolymers holds promise for some very interesting developments in the intermediate period ahead. Here, a polymer can be tailored to combine the best properties of two monomers.

Polymer chemists are never quite satisfied though. The technology for making polymers out of hydrocarbons is not quite fully developed, when already some are thinking about making polymers out of silicates. Their reason? Simple enough—there are an awful lot of silicates around.

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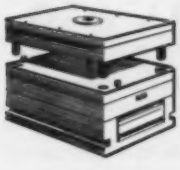

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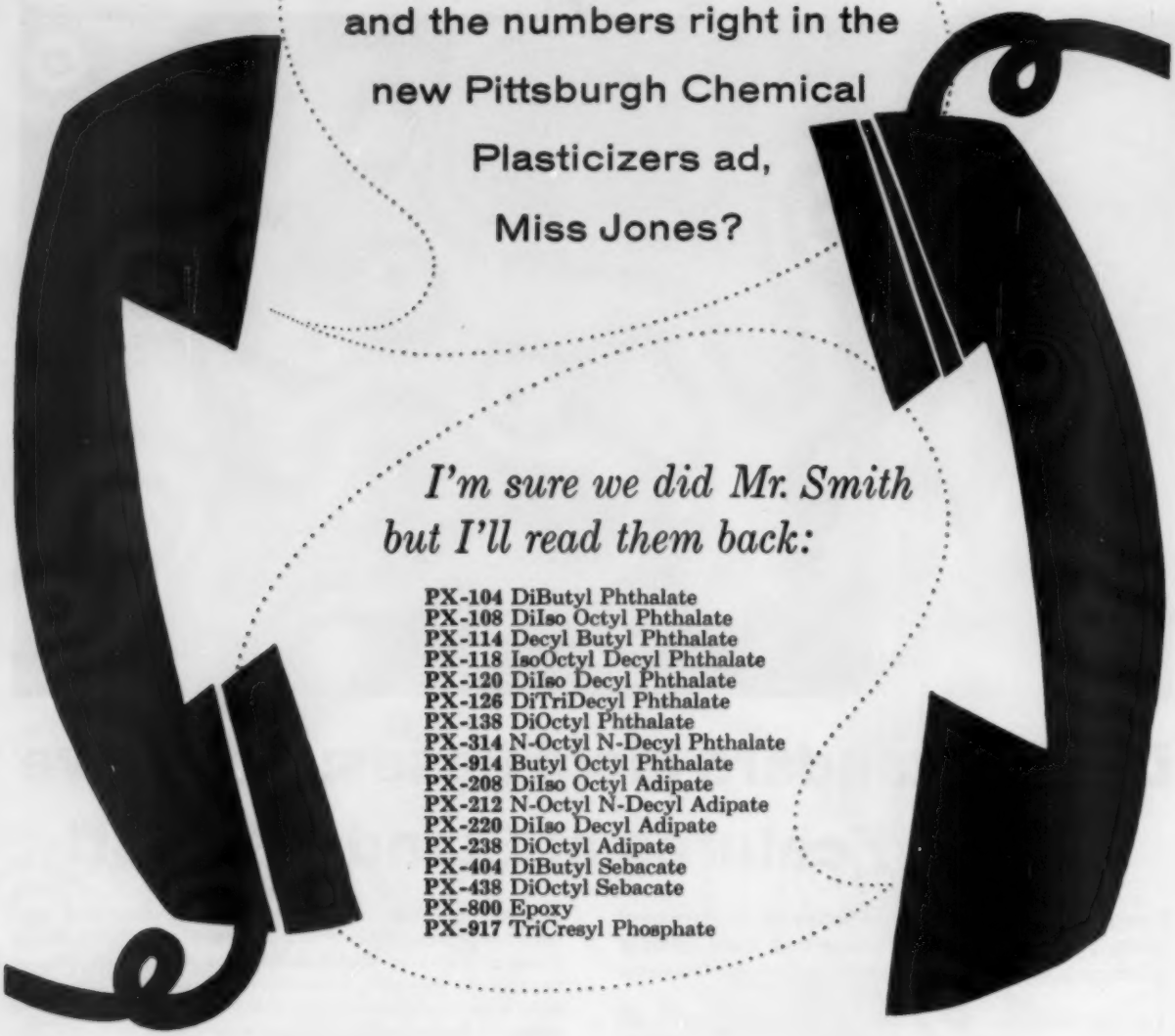

I'm sure we did Mr. Smith but I'll read them back:

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Letters

Dear Sir:

Thank you very much for printing Mr. Morse's story, "Movable Screw Plasticizing Boom". It is a most interesting and controversial subject. I was fortunate enough to attend the SPE meeting in Cleveland, at which Mr. Morse gave his speech on this subject. We would appreciate receiving from you twenty five (25) copies of the reprints of Mr. Morse's article. If it would be possible we should rather have twenty five (25) extra copies of the June issue of the SPE Journal, as the issue contains numerous articles that are of interest to us in Cleveland and also to our foreign affiliates. By the way, I am a member of the SPE and I also am a subscriber to the Journal.

D. Gauw
Product Engineer
Ferro Corporation, International Division

Dear Sir:

I read with great interest your article, "The New Mold, Its Problems and Some Solutions" which appeared in the July issue of the SPE JOURNAL.

Congratulations on an excellent presentation.

John J. Keville,
Director of Marketing
Ludlow Plastics

Editor's Note

The following letter is an answer to the comments of Jack G. Fuller and Dr. H. Frimberger which appeared in last month's column. Their letter referred to the article "Movable Screw Plasticizing Boom?" by A. Reynolds Morse.

Dear Sir:

Unfortunately your correspondents have lifted most of their commentary from its context so as to distort its meaning. A single example will suffice. They imply that my article said *all* movable screw cycles were 10-20% longer than plunger type. What I *actually* said was that *in Europe* mold cooling is still relatively inefficient, as cycles are conventionally from 10-20% longer than in America.

What I have seen on this present trip only reaffirms my original observation: European production demands and molding cycles just cannot be compared to American production speeds. This means to me that movable screw injectors (which have been in use for several years here) have not yet been rigorously tested under typical rough and tumble competitive molding conditions which characterize American injection molding.

I stand by my original conclusion: movable screws are especially well suited for specialty molding conditions, particularly on thermally difficult materials where low wattages are most desirable.

In connection with your correspondents' extremely serious charge of bias, it should be observed that as author of the article on movable screws I had nothing to gain or lose by recording my independent appraisal of a development vital to the American Injection Molder, as we do not make injection molding equipment of any type. We do, however, adapt specialized components to *all* types of injection machines so that we have a broad familiarity with the injection molding equipment picture. With no basic equipment to buy or sell, we are probably better qualified to appraise a total situation like this than the representatives of any single machine company.

Before I ordered *any* movable screw machine I would make absolutely certain that I had a good sound application for it that would assure an immediate return on the some 35 to 50 thousand dollars I would be tying up.

Injection Molders Supply Co., Inc.
A. Reynolds Morse, *Pres.*

Sparks of Interest in Fire Retardancy

Dear Sir:

Please send us five copies of the article, "Rigid Polyurethane Foams and Fire Retardancy" which appeared in the September issue of the Society of Plastics Engineers Journal.

Denise T. Malone
Technical Service Laboratory
Ciba Products Corporation

Dear Sir:

I would appreciate receiving a copy of "Rigid Polyurethane Foams and Fire-Retardancy" which appeared in SPE Journal, September, 1961, pages 965-8.

Frank B. Slezak
Research Department
Diamond Alkali Company

Dear Sir:

Please send us two copies of your up-to-date survey of what is happening in the field of build-in-fire-retardant polyurethane foams, as advertised in your September issue of SPE Journal.

T. H. Evans
Manager–Market Research
Naugatuck Chemicals

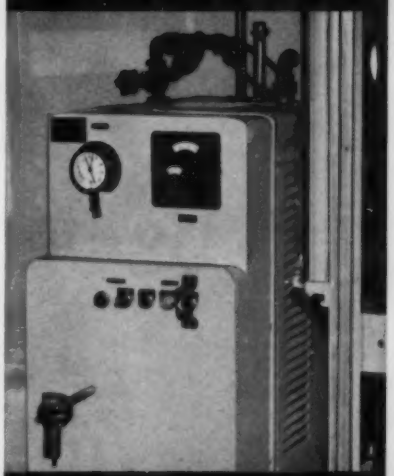
Dear Sir:

In the September, 1961, issue of SPE Journal your special feature article is on "Rigid Polyurethane Foams and Fire-Retardancy". This very excellent article was staff written by Mr. Louis I. Naturman, your technical editor, and you very kindly offered additional copies.

I would appreciate it greatly if you would send me four copies of this article.

E. M. Eriksen
Advertising Assistant
Metal & Thermit Corporation

IBM ENDICOTT PLANT USES STERLCO TEMPERATURE CONTROL UNITS FOR ACCURATE MONITORING OF PLASTIC MOLDS



Stator Blocks for the IBM 407 Accounting Machine are molded on a Logan Press, with a Sterlco Model 6016 maintaining accurate mold temperatures.

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The Sterlco Model 6016, selected by the IBM Plastics Laboratory, Endicott, New York, to assure accuracy of delicate plastic components, is a single zone circulating unit with a temperature range of 100° to 550° F. Heat transfer fluid temperature is maintained by an immersion type heater of 12 KW capacity. Circulating pump is heavy duty, slow speed positive displacement type. There are Sterlco units to provide the same efficient, low-cost service for you . . . whatever your temperature control needs may be!

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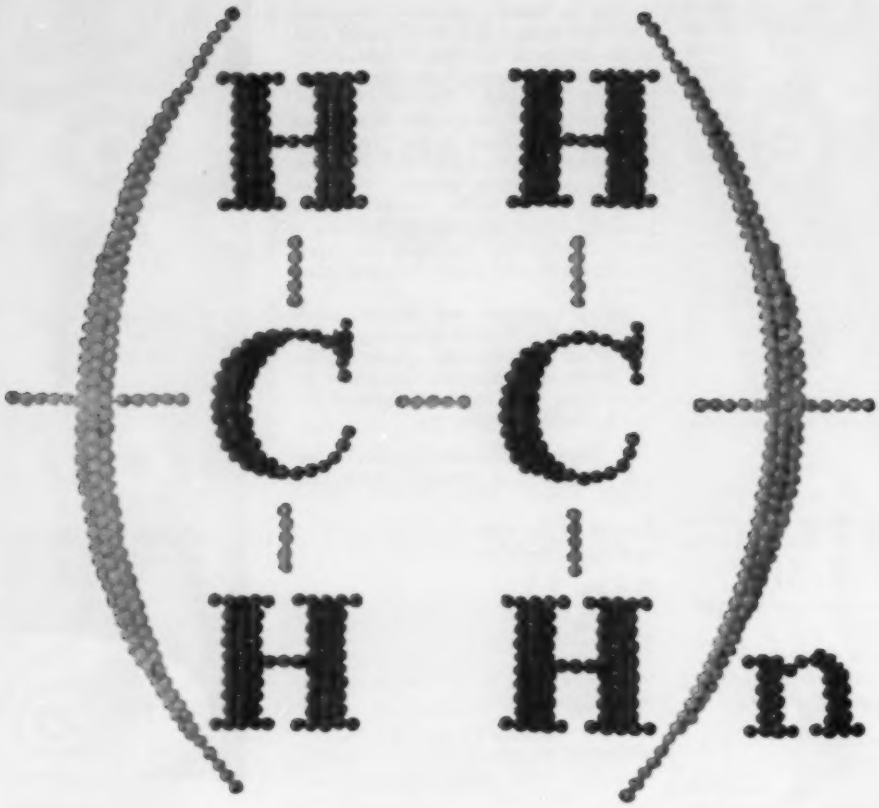

THAT EXTRA TOUCH OF GRACE: Technical Information

The flood of daily data about new plastics resins, equipment and developments in molding and fabricating seems never-ending. How can any one person keep up with it? The Grace staff is prepared to help plastic resin customers in their search for specific technical information. Your Grace representative offers a variety of Grace publications plus the literature resources of the Grace libraries. This is another of the ten major services available under the Grace Service Plan; your representative has details.

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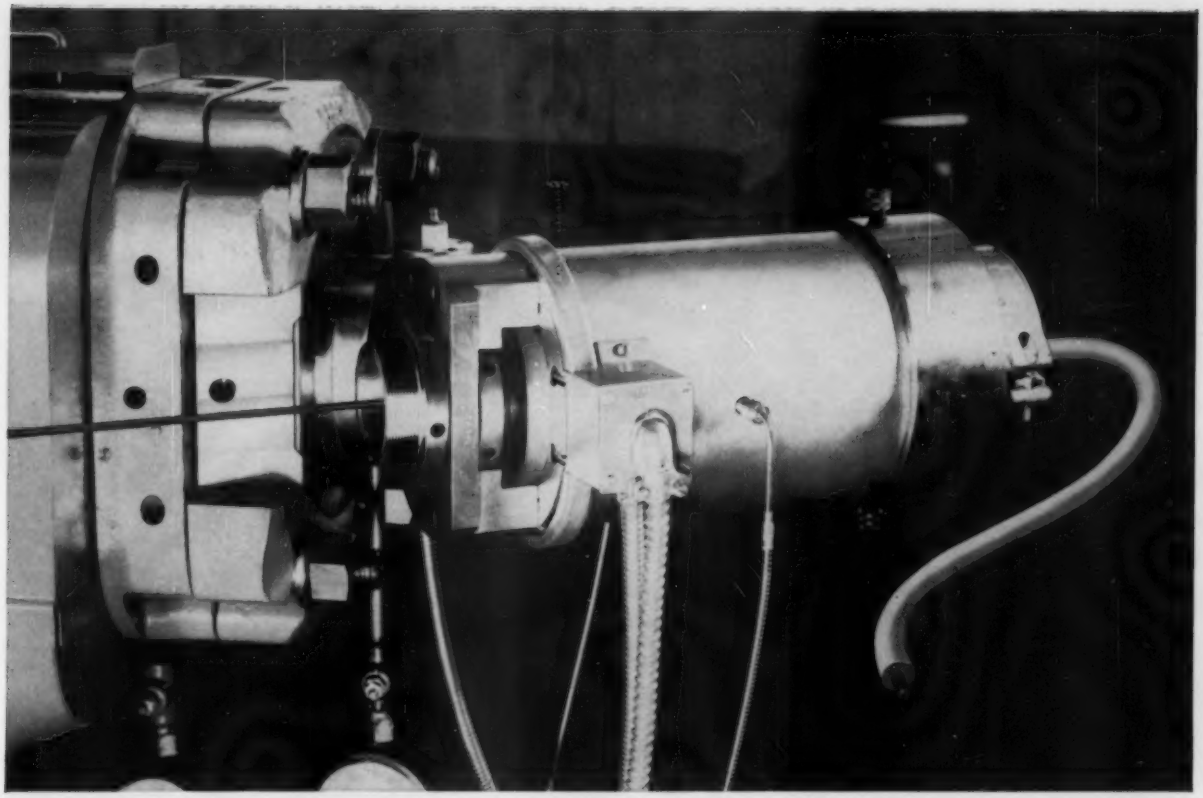

"XL" Grade Stabilizers: practical way to improve appearance, upgrade performance of vinyl insulations

Add an extra measure of heat stability...without changing your approved formulations

It's easy to see how an "XL" Grade Insulation Stabilizer improves the appearance of a vinyl compound. Improved natural color shows up clearly when you compare stacked spools of insulated wire side by side with regular stabilizer stocks. The upgraded color is remarkably well retained through processing and aging. Electrical and physical properties are kept at superior levels through heat aging. Faster extrusion rates are possible.

Unusually high heat stability of "XL" Grade Stabilizers helps provide these and other advantages. Their superior heat stability has now been definitely established in commercial use.

Can you profit from this extra margin of heat stability? With "XL" Grade Insulation Stabilizers, you can increase on-wire resistivity, provide performance that exceeds industry standards. It may be possible to upgrade certain insulation formulations to the next highest class. And you can "build in" desired improvements without changing approved and established compounds.

Your own wire extrusion studies can show you how the "XL" Grades combine improvements in appearance, electrical, physical and mechanical properties. For more information, simply mail the coupon below. *Trademark

DYTHAL® XL Stabilizer for all classes including 105°C primary insulations.

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TRIBASE* XL Stabilizer for critical heat stability up through 90°C insulations.

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In Canada: CANADIAN TITANIUM PIGMENTS LIMITED
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Gentlemen: Please send information on "XL" Grade Stabilizers for vinyl electrical insulations.

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New Curtiss-Wright Mark II BETAMETER®

Measures Basis Weight and Thickness . . . Only $4985.

BetaMeter in operation measuring 0.00025" film thickness

The Curtiss-Wright Mark II BetaMeter takes the guesswork out of basis weight or thickness measurements in the production of coated stock, paper, plastic or similar sheet products, making it unnecessary to apply "more than enough" to be sure of meeting specifications. In the manufacture of extruded products, close tolerances are maintained to ensure correct length yield per pound.

This economical BetaMeter utilizes radioactive isotopes to measure actual production quality without contacting the material or affecting the process in any way. Weight or thickness variations across the sheet are detected instantly, enabling the operator to make immediate corrective adjustments. The Result: Faster start-ups and grade changes, reduced scrap losses and more uniform quality products.

The $4985 price includes control console, recorder, and BetaMeter on "C" frame for handling up to 36" webs. Other frames for larger webs are available at reasonable cost. Automatic process control equipment is manufactured for the BetaMeter and all other standard Curtiss-Wright measuring systems.

Increase your profits through better quality control with the economically-priced Curtiss-Wright BetaMeter - phone SWinburne 9-0500 or write.

Princeton Division CURTISS WRIGHT CORPORATION Princeton, New Jersey

IN CANADA: Canadian Curtiss-Wright Ltd., Industrial Process Controls, Davis Road, Oakville, Ontario.

SPE JOURNAL NEWSLETTER

reading time
1 minute

Polypropylene Chairs

Molded contour polypropylene chairs are being offered by Alladin Plastics. Functional, durable, weather resistant and easy to maintain, they have the significant advantage of attractive pricing. Each chair contains about three pounds of resin. Alladin estimates production of one million chairs this year.

More on Isocyanates

Kuhlmann of Paris and du Pont will form a new French company, called Dekachimie to manufacture and sell isocyanates. Scheduled to be completed by 1963, the six million dollar plant is expected to help serve the European Common Market. In Japan three companies have been granted permission to import foreign technology for local TDI production.

High Temperature Adhesives

The addition of a reactive inorganic curing agent such as arsenic pentoxide to a reactive prepolymer rather than polymerization of semi-inorganic monomers produces a high molecular weight semi-inorganic adhesive. Useful structural properties at temperatures up to about 1000°F. are obtained. Good oxidation resistance, important for heat stability, was displayed with an epoxy novolak-silicone phenolic polymer at Narmco Research and Development Division.

Long Term Strength of Reinforced Plastics

Effects of erosion moisture and temperature change limit the ability to predict load bearing ability over extended periods of time. Accelerated tests at American Cyanamid's Research Laboratory, using the progressive loading (Prot) method have indicated reasonable agreement with actual long term data. This new analysis is valuable for determining the effects of formulation and fabrication.

Plastics Research

The Koppers Company dedicated a new research laboratory in late August. Among the plastics research projects being given considerable attention: Development of boron compounds for use in catalysis and polymer formation; a plasticizer based on phenanthrene; and a low molecular weight epoxy, butadiene dioxide. Koppers also expects to be a significant factor in developing plastics for buildings with its self-extinguishing expandable polystyrene.

To meet the new growth spurt in plastics . . .

MONSANTO'S PLASTICIZER EXPANSION

guarantees for years ahead:

1. Dependable Supply of Plasticizers

No more shortages! Monsanto's "older" plasticizer plants have been enlarged periodically. A new Monsanto facility at Long Beach, California, recently started delivery of phthalate and adipate esters. An even larger new plasticizer plant in Monsanto, New Jersey, will soon be on stream.

2. Raw Materials, Too

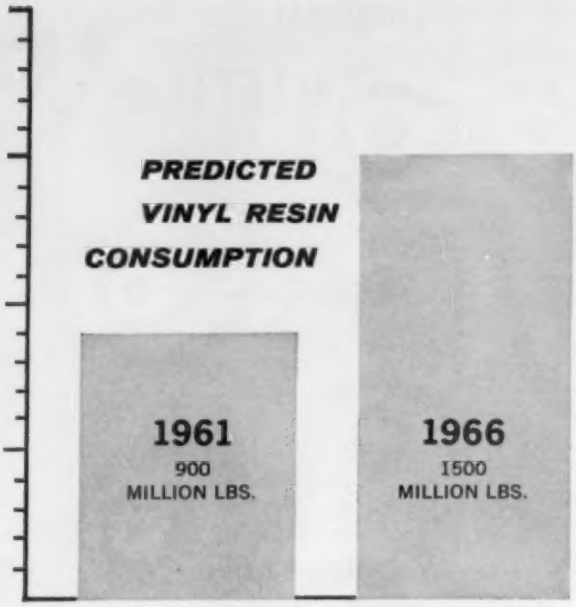
We'll start making our own naphthalene, alcohols, and other basic plasticizer ingredients at Chocolate Bayou, Texas, in 1962. Furthermore, we'll boost our output of phthalic anhydride upon completion of new facilities at Monsanto, New Jersey.

3. Absolute Quality Control

Monsanto's *complete control* of production from raw materials through intermediates to end products will assure consistent top quality at every stage of production.

4. Money-Saving Advantages

Lowest plasticizer costs are assured by Monsanto's total integration into all raw materials. Consider these other cost-cutting benefits: mixed shipments in tank trucks, tank cars, or full loads of drums • premixed *blends* of multiple-component plasticizer systems • engineering assistance on bulk-handling facilities *at your plant* to reduce labor, spillage, and other handling costs • fast deliveries from nearby bulk-storage stations.



5. Plasticizers for Every Need

Monsanto makes more plasticizers than anybody else (*more than 80!*)—including such outstanding performers as *Santicizer*® 409 polymeric plasticizer for permanence; *Santicizer* 160 for stain-safe floor tile; and *Santicizer* 141 for fire retardance, nontoxicity, fast processing, and weatherability. As more-demanding performance requirements arise, Monsanto researchers develop new plasticizers to meet new challenges.

6. Priceless Technical Assistance

Monsanto's Plasticizer Council staff brings to bear a total of more than 250 years' experience in plasticizing technology. Day after day, in a fully equipped special laboratory, they pursue their primary mission: *to help our customers select plasticizing systems for optimum cost/performance.*

MONSANTO CHEMICAL COMPANY
Organic Chemicals Division
Plasticizer Council, Dept. 4461-V
St. Louis 66, Missouri

Monsanto®

Please rush me a copy of ☐ *"Plasticizers . . . to Help You Grow with Plastics"* and ☐ Technical Bulletin PL-314 on *"Bulk Receiving of Plasticizers."*

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Company.....

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City..... *Zone*..... *State*.....

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add sales appeal to paints, plastics, inks, rubber

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Benzidine Yellows				
Pigment Yellow			■	■
Permagen® Yellow	■	■	■	■
Permanent Yellow		■	■	■
Benzidine Orange				
Permagen Orange		■	■	■
Dianisidine Orange				
Permagen Orange		■	■	■
Permanent Red	■		■	
BON Reds				
Permagen Red		■	■	■
Dioxazine				
Permanent Violet	■	■	■	■
Naphthols				
Helio® Red		■	■	
Naphthol Red		■	■	
Permanent Red	■	■	■	■
Permanent Carmine	■	■	■	■
Parachlor Red				
Pigment Red	■		■	
Phthalocyanines				
Heliogen® Blue	■	■	■	■
Heliogen Green	■	■	■	■
Heliogen Viridine	■	■	■	■
Pigment Scarlet				
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* A partial listing of pigments from GDC. For further information contact your local GDC Technical Service Representative.

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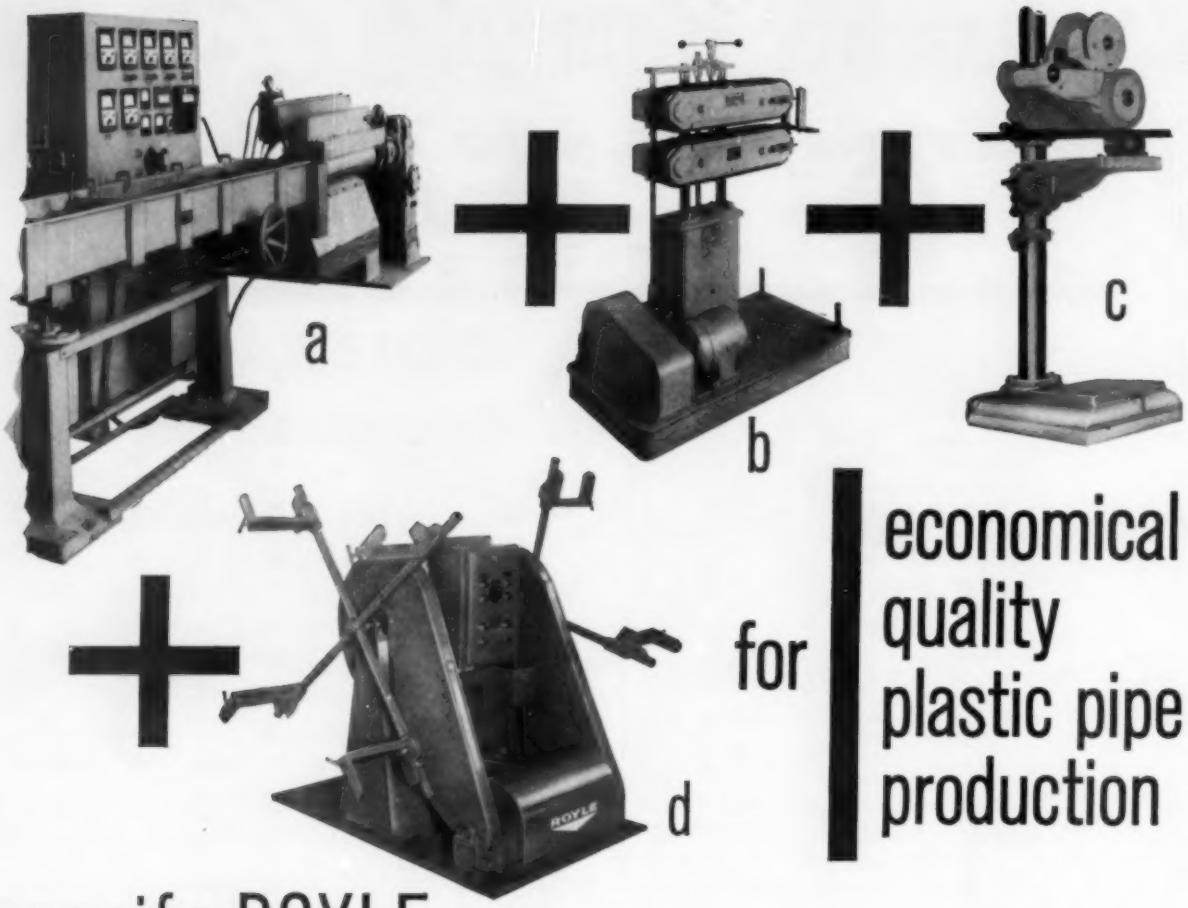

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If you produce plastic pipe—polyethylene, rigid or semi-rigid PVC, Kralastic, Cycolac, nylon, polypropylene or any other compound—choose Royle equipment. Now you can get Royle quality—Royle dependability—Royle performance along your entire pipe production line—from hopper to finished plastic pipe. Every unit supplied by Royle functions perfectly with every other unit . . . Extruders, Master Control Panel Boards, Cooling Tanks, Pipe Take-Offs and Coilers. So, for customized Pipe and Profile Extrusion Systems—get Engineered Equipment—join the swing to Royle.

a Royle Spirod® Extruder—2½" cylinder bore. L/D 24:1—with Master Control Panel and Cooling Tank equipped with sizing rings. **b** Modified to meet Royle specifications, the Farris Electronic Variable Speed Take-Off has been selected as the best qualified for this function. These Take-Offs handle rigid and semi-rigid pipe in a range of sizes from 1" to 8". **C** Matthews Offset Printer. For positive identification of rigid and semi-rigid plastic pipe. **d** The new Royle Dual Coiler developed to coil flexible pipe or tubing. It features collapsible coiling heads, electric clutches for engaging heads, pre-wired operator's control station and constant torque drive.

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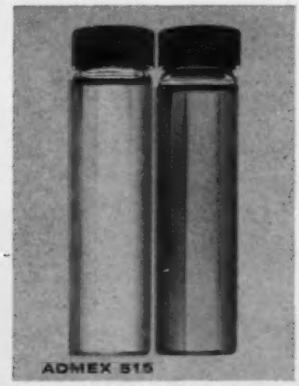
Woaldstone, Middlesex, England, James Day (Machinery) Ltd., Harrow 2655-6. **Home Office,** V. M. Hovey, J. W VanRiper, SHerwood 2-8262. **Akron, Ohio,** J. C. Clinefelter Co., Blackstone 3-9222. **Downey, Cal.,** H. M. Royal, Inc., TOpaz 1-0371. **Tokyo, Japan,** Okura Trading Company, Ltd., (56) 2130-2149.

Arizona exposure test proves Admex 515 permanence best under the sun!



LIGHTER COLOR. *Admex 515 color averages 3 to 5 Gardner ('53) tubes lighter than competitive plasticizers. This gives you clean, light color in compounds, ideal for white and pastel products.*

Clearly superior color...freedom from exudation

There's a lot of talk about plasticizer permanence . . . but here you really see it! The photos above show two clear vinyl films (both 50 PHR) after 6 months' Arizona exposure: one containing Admex 515, the other a well-known competitive polyester plasticizer.*

Compare them. Note the nearly clear condition of the Admex 515 film . . . the drastic deterioration of the other. At a glance, the functional superiority resulting from Admex 515's unique light stability is obvious. For resistance to heat, light and humidity; gasoline, mineral oil and solvent extraction, Admex 515 is definitely outstanding. And just as important in many applications is the light color of Admex 515—3 to 5 Gardner tubes lighter than competitive plasticizers.

Other features of Admex 515 include low temperature flexibility, low, stable viscosity, good pigment wetting and economical price. Combined, these functional advantages make Admex 515 ideal for: coated and calendered upholstery, pigment dispersions, electrical insulation, paper coatings, profile extrusions, dipping compounds, vinyl foam.

If a superior plasticizer for any of these applications would help you profit, write, wire or call us today. We'll send you a sample of Admex 515 and complete information on this unique product.

**Test panels were 45° South, direct to the weather.*

Archer-Daniels-Midland
CHEMICAL GROUP
752 INVESTORS BUILDING
MINNEAPOLIS 2, MINNESOTA

RUSSIANS SEE

AMERICAN PLASTICS IN MOSCOW

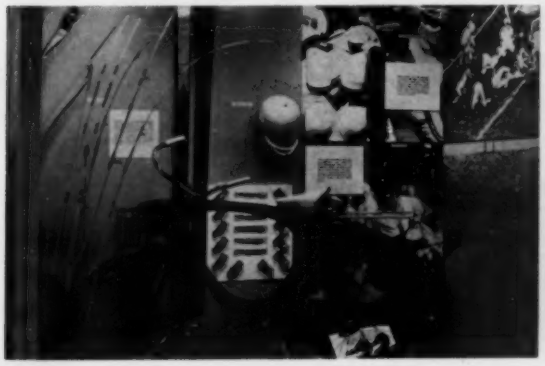
Three SPE members contributed to the success of the United States Information Agency's (USIA) Exhibit, "Plastics—U.S.A." held in Russia this past Summer. George Lubin, Grumman Aircraft Corp., who took the photographs on these pages, travelled with the Exhibit for several weeks and was a technical consultant. Another SPE member, Armand G. Winfield, DeBell & Richardson, Inc., was Technical Director, and Dr. Irvin Wolock, The Naval Research Laboratory, also served as a technical consultant. Co-sponsoring the Exhibit, under the auspices of the USIA, were SPE and SPI.

The Story of American Plastics. Armand Winfield, with the aid of an interpreter, conducts an informal lecture at the Exhibit which drew thousands of interested Russians each day.

American Plastics-At-A-Glance. A dramatic view toward the front of the exhibit, showing plastics statistics displays in the foreground; multitude of applications in the center.

All About Plastics. Visitors crowd Exhibit floor dominated by a Geodesic Dome. Interest was high at the Commercial Aviation and Sports booths.

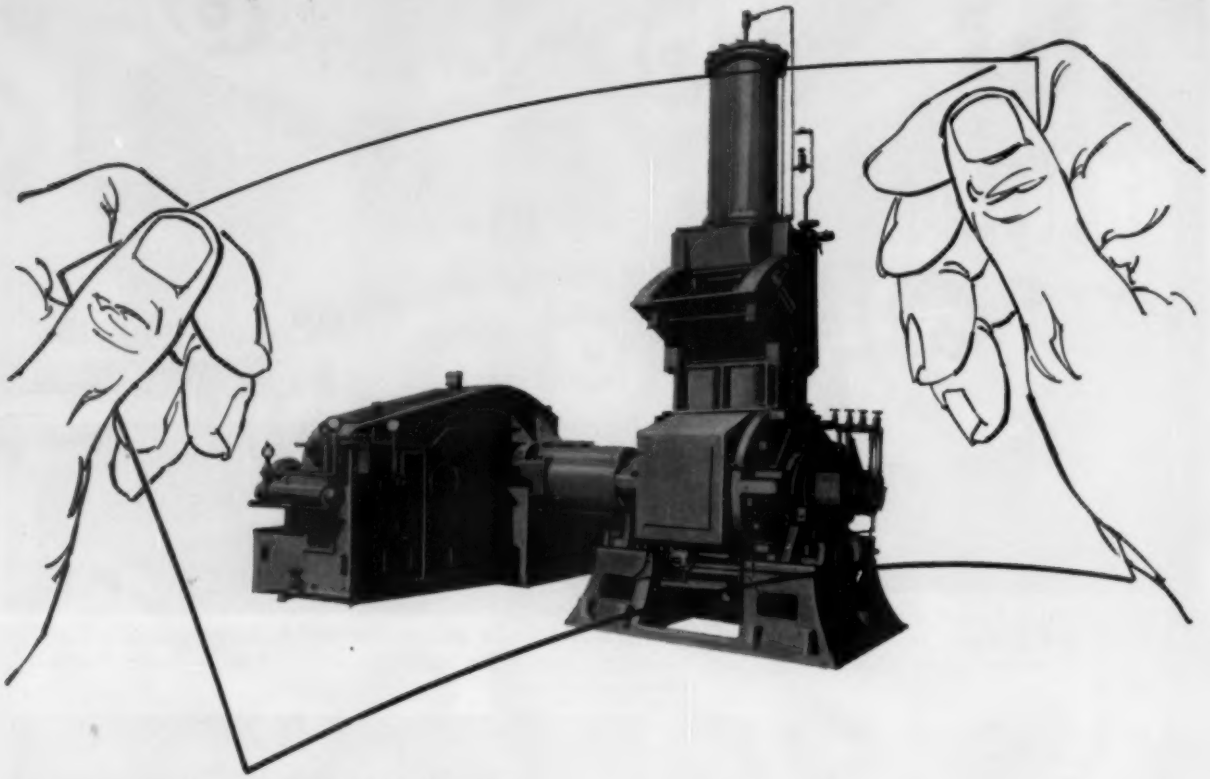
Plastics and Medical Science. Display, featuring prosthetics, pinpointed progress in the use of plastics as an aid to the medical and dental professions.



Speaking of Sports. Wide use of plastics by American Sporting Goods Manufacturers drew comments and conversation in both languages!

Objects of Art . . . in Plastics. Arranged by Armand Winfield, the most recent use of plastics as a material of art was displayed in its many forms.

A SKILLED HAND IN CHEMISTRY . . . AT WORK FOR YOU



METASAP *puts these characteristics in your polyvinyl chloride compounds*

- **Heat and light stability**
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If your formulations demand specific heat and light stability, controlled lubrication, clarity, good initial color, or freedom from sulfide staining, look to Metasap for the answer to your problem.

The Metasap Division of Nopco Chemical Company produces a complete line of powdered and liquid products for the stabilization of polyvinyl chloride compounds. Metasap stabilizers are adjustable to the needs of your formulation and can be tailored to your processing conditions.

The name Metasap has been synonymous with quality since 1917. Our experience and technical assistance are at your disposal in solving processing problems. Write for further information on Metasap[tm] polyvinyl chloride stabilizers.

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METASAP™

SPE Meeting To Highlight Vinyl Plastics

Vinyls, one of the billion pound materials of the plastics industry, will be the subject of an SPE Regional Technical Conference on November 15, 1961. Sponsored by the Society's New York Section with the cooperation of the Vinyl Plastics Professional Activity Group, the Conference on "Vinyl Plastics in the Household" will be held at the Statler-Hilton Hotel in New York City.

Papers selected for presentation at the Conference cover both vinyl applications, for example, flooring and telephones, and vinyl technology including standards, color matching and new materials. Of particular interest, according to RETEC Co-Chairman Saul Gobstein of Ferro Chemical, is a paper entitled "Formulation of Low Staining Flooring Compositions" which reveals for the first time new developments in the continuing effort to minimize staining of vinyl flooring. Also on the program is the first formal presentation of results of a recent and extensive study of "Hi Temp Formulations from End Use Considerations". In addition, Frank W. Reinhart of the National Bureau of Standards will present an up to date compilation of current standards for vinyl plastics.

RETEC Co-Chairman Roy L. Kern, Thompson Chemical Co., has indicated that the luncheon speakers will be James R. Lampman, SPE Vice President, Engineering, and another speaker to be announced at a later date.

The complete technical program as announced by Program Chairman Irwin L. Podell of Irwin L. Podell, Inc. follows:

VINYL PLASTICS IN THE HOUSEHOLD

November 15, 1961

Statler-Hilton Hotel

New York, New York

8:00 a.m.— *Registration*

9:00 a.m.— *Welcome to Vinyl RETEC*
Roy L. Kern
Thompson Chemical Co.

Morning Session

9:10 a.m.— *Moderator:* Irwin L. Podell
I. L. Podell, Inc.

Vinyls in Telephone Usages
John B. deCoste
Bell Telephone Laboratories

Effects of Fillers on Properties of Vinyl Flooring Compositions
A. W. McKee
Armstrong Cork Co.

Formulation of Low Staining Vinyl Flooring Compositions
Joseph Fath
Thompson Chemical Co.

Vinyl Plastics Standards
Frank W. Reinhart
National Bureau of Standards

12:00 noon— *Reception*

12:30 p.m.— *Luncheon*
Moderator: Saul Gobstein
Ferro Chemical
Comments: James R. Lampman
SPE Vice President, Engineering
(General Electric Co.)
and
speaker to be announced

Afternoon Session

2:30 p.m.— *Moderator:* Robert A. Abeles
Elfskin Corp.

Effect of Processing Conditions and Plasticizer Choice on Physical Properties of PVC
Peter W. Spink
Monsanto Chemical Co.

Hi Temp Formulations from End Use Considerations
Robert T. Holtz
B. F. Goodrich Chemical Co.

Correlation of Vinyl Light Stability Data
Abe Scarborough
National Lead Co.

CIE System of Color Measurement, as Used for Practical Production Color Match Problems
R. Landry
Davidson & Hemmindinger

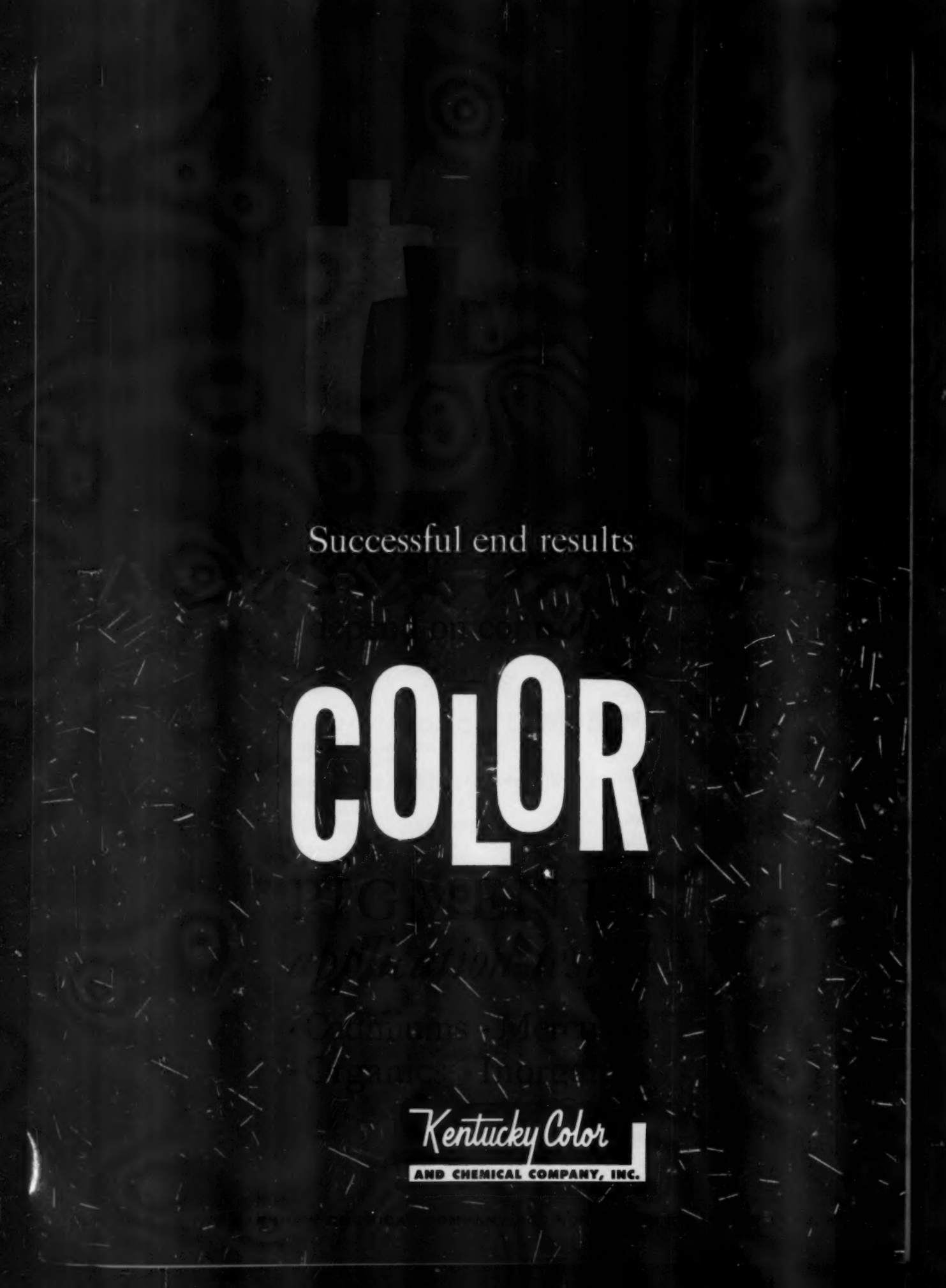
Conference registration fees, which include luncheon and a copy of the RETEC preprint book, are as follows:

	SPE Members	Non SPE Members
Advance Registration	$12.00	$14.00
On-site Registration	13.00	15.00

Requests for further information and advance registrations should be directed to:

Melvin M. Gerson
RETEC Registration Chairman
c/o Sandoz, Inc.
61 Van Dam St.
New York 13, N. Y.

Chairman of other major Committees responsible for planning and producing the RETEC are: House, Walter Schalk, Monsanto Chemical Co.; Membership, Leonard Nass, Advance Solvents & Chemicals Co.; Printing, Alva E. Whitney, Goodyear Tire & Rubber Co.; Publicity, Michael Saggese, J. P. Frank Chemical Co.; and Treasurer, Robert Braddicks, Kentile Inc.


Successful end results
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SPECIAL FEATURE

Reclamation of Thermoplastics

Thermoplastic Reclamation . . . By whom and for whom? This SPE Journal feature reports on the market, processes and structure of the secondary plastics material industry

Louis I. Naturman
Technical Editor

One of the foremost considerations in any manufacturing activity is the proper utilization of waste from production and processing operations. Since there is a considerable amount of waste developed in the processing and production of thermoplastics and since thermoplastics, by their very nature, can be reprocessed, there is a rather sizable secondary plastic reclamation industry.

Where Does the Material Come From?

There are many sources. Much of the material available today is the result of the operations of the prime resin manufacturers. In the production process, off-specification material is obtained. Some of the common specifications which are not always met are color, melt index, and density; start up and shut down material can also be included. Additional material is made available as a result of floor sweepings and residues from processing machines which are not recirculated. This type of material is sold to plastic material reclaimers in various grades.

The extruder or molder generally generates scrap, in the form of runners, sprues, punch-outs, flash, and rejects, along with thermoplastic lumps from his bleeder. Film and sheet trimmings and off-colors and gelled film are other major sources. In certain instances, this material is either reclaimed by the fabricator himself or sent to a reprocessor who will do custom reclamation for him. Because of the low prices for plastic scrap and the desire to save on material costs, many processors have been recovering as much material as is economically possible. *Table 1* lists the main sources of plastics from processing operations.

Distribution

Off specification material is handled in various fashions. Certain processors purchase virgin off specification material which they grind, color and blend to customer specification; this group can also act as distributors. A smaller percentage will purchase scrap from fabricators and then trade or reprocess this material for resale. In many cases material for resale may be a blend of virgin and secondary material. In addition, some companies in this industry do custom processing of primary scrap material for those molders and extruders not large enough to do all their own work or who require special processing. This is done on a fee basis reportedly ranging from 7 to 15 cents per pound, depending on the complexity of the operation. It is estimated that about 40 million pounds of material are handled this way with emphasis on polyethylene, polystyrene and polyvinyl chloride.

The distributor, reprocessor and scrap dealer are all links in the secondary plastics distribution chain. Some of the larger outfits handle all facets of the business and some concentrate on one particular aspect. Others handle all the thermoplastics materials and some limit their operations to big volume items such as polyethylene and polystyrene. Many of these secondary material handlers are in other phases of the plastics material business e.g. reprocessors will do primary virgin coloring on a customs basis for either the material supplier or the user.

The Recovery Process

The type of material obtained is as varied as are the outgoing requirements, therefore the recovery process is not always the same. The recovery operation may involve any combination of the following steps: grinding, cleaning, separating, pelletizing, blending and coloring. Some companies install an entire processing system in their plant while others

Table I. Major Sources of Plastic Scrap Internally Generated By Molders and Extruders

Polyethylene	— Film scrap, purging lumps and regrounds.
Vinyls	— Film and sheet trimmings, terminal material, bleeder material and pipe.
Cellulosics	— Sheet scrap, vacuum forming scrap from optical manufacturing.
Polystyrene	— Sheet, terminal material, trim and edges.
Acrylics	— Sheet trimmings and terminal material.
Nylon	— Purging lumps and rejects and terminal material.
Polypropylene	— Purging lumps and rejects and terminal material.

Table 2. End Use Pattern (Estimated) for Secondary Polyethylene

Toys	35%
Housewares	25%
Secondary Pipe and Blowmolding	15%
TV wire	5%
Film	5%
Flowers and Jewelry	5%
Miscellaneous	10%
	100%

send out certain phases of their recovery operation to other processors.

In general, there are three types of materials which a plant handles for reclamation. They are; (1) virgin off specification material and sweeps that are in pellet form, (2) rejected film and (3) thermoplastic lumps from purging operations, obtained from molders extruders and material suppliers and rejected parts.

The pellets are cleaned in a screen and/or an air separator arrangement. They are then ready for further processing. This material is sometimes sold as is (if color and other properties are acceptable); alternately it can be extruded with some pigmenting material and pelletized.

The film is separated by cutting off the printed and colored parts from the uncolored or clear strip and each fraction so obtained is then treated separately; the colored segment goes through a Banbury mixing operation with pigmentation material generally, thence to an extruder and pelletizer. The clear segment often short circuits the Banbury and goes to the extruder but it can best be handled in the Banbury.

If lumps or odd shapes are involved the material is sent to a grinder from which it is transported (possibly by a blower) to the Banbury for further processing. Further blending can then be performed on these products, depending on the customer's requirements.

This procedure is a blending operation in many respects. Therefore, the success of the operation can depend upon the knowledge and experience of the processor. In many cases it will be necessary for him to blend with primary virgin to obtain the right formulation. He must be knowledgeable in the art of coloring and he must be able to buy material on his specification; here he must be aware of the possibility of buying degraded and impure material which can do him great harm. Furthermore, he should be able to furnish a similar finished product on a repeat order to his customer although he may not have the same starting material

In most cases the secondary material is colored to a customer specifications. Off colored material is generally processed to a darker color with the dark blacks and greys becoming the last resort for darker multi-colored raw material.

Density and melt index are controlled by blending operations. In the case of polyethylene, for example, linear may be blended with conventional. With polystyrene and poly (vinylchloride), plasticizers and softening agents may be added. The addition of wax to polyethylene as a softening agent is not a general practice in the industry. Less expensive grades of polystyrene are generally loaded with filler. The type of product obtained depends on the material used, and in most cases is reflected in the price of the finished product.

Many of the plastic reclamation houses assert that they are in a position to up-grade the material to a point where it is not only comparable to prime virgin but to where it has a "certain something" added. In effect, this procedure may involve obtaining a specific color or a certain melt index value or density which the reclaimer has achieved via a blending operation. Actually up-grading in this context is only a euphemism for custom compounding where the raw material is mainly secondary thermoplastic material.

In all these operations there is a great deal of variability depending upon the type of raw material purchased and processing methods utilized. Most of the recovery houses do incorporate some degree of quality control into their operations. Color, melt index and density are the specifications which are most carefully followed. Some of the reclaimers will have some degree of technical service equipment, such as a film extruder to test the efficacy of their finished product in actual service.

Uses

In general these recovered materials are not used for critical items which includes government specified parts and other parts requiring close tolerances and where low shrinkage is desired. In some cases 100% of reprocessed material is used and in some cases reprocessed material is mixed with primary virgin, the percentage of which is determined by price, availability, properties of available material on the one hand, and the rigidity of specifications on the other. For polyethylene, the end use pattern is estimated in *Table 2*.

Uses for other reprocessed thermoplastics are not as clearly delineated, but the better known applications are are as follows:

Vinyls—Pipe, hose, seat covers, pocketbooks, rain gutters, trimmings, weather stripping.
Polystyrene—Toys, housewares, jewelry
Cellulosics—Eyeglass frames, jewelry, buttons, pencils, toys, tool handles, hair curlers
Acrylics—Jewelry, appliances, eyeglasses
Nylon—Hardware and toys
Polypropylene—Houseware and hardware, toys

There are myriad of uses for these secondary materials, especially where the finished parts are expendable (e.g. toys, tool handles).

For rigid specifications involving reproducibility, quality control and close tolerance and where FDA restrictions are involved, use of secondary material is generally not advised.

Location

Most of the reprocessing companies are concentrated in two areas, the

Table 3. Price Range of Recovered Thermoplastics—at time of writing (quantity prices are quoted)

	Range ¢/lb.	Virgin clear ¢/lb.	Virgin colored ¢/lb.
Polyethylene	15-24	26*	35
Polystyrene	13-23	18-35**	22-39
Polyvinylchloride (molding)	8-19	18-21	—
Cellulosics	20-35	40-63***	—
Nylon	40-70	98	1.12****
Polypropylene	25-38	42	51

* base price for conventional
** higher prices are for higher impact material
*** 63¢ for butyrate and propionate
**** black is $1.05

Table 4. Savings in Raw Material Costs

Cost of Raw Material % of Sales	Savings in Raw Material % of Material Cost	Savings in Cost of Goods Sold % of Sales
20	20	4
	30	6
	50	10
30	20	6
	30	9
	50	15
40	20	8
	30	12
	50	20
50	20	10
	30	15
	50	25

Note: Other processing costs are assumed constant here.

Midwest and the New England, New York—New Jersey areas. These two areas are situated in both cases close to the market and in some cases near the source of supply. In some cases virgin material is shipped from southern warehouses and plants. As the price of the material is lower than virgin, transportation costs become more significant. Material is sometimes purchased at an intermediate point and shipped directly to the market area where it is processed on a custom basis by a local processor if the original purchaser is in another area. It has been estimated that about 50% of the reclaimed material is processed in the northeastern part of the U.S.A., 35% in the midwest and 15% in the rest of the country (most of this 15% is concentrated on the west coast).

A good deal of material is sent overseas, an outlet for the lowest grade material it is claimed. Most of this trade is in polyethylene and polystyrene. 15% of the reprocessed material is exported, according to industry estimates.

Price Structure

The price schedule of reprocessed material varies quite considerably depending upon the market for primary virgin material, availability of all thermoplastic material, processing requirements, competition from other dealers and virgin resin suppliers and type of material sold. In general the prices of the dark-colored products are cheaper, whether they are scrap or off specification virgin origin, due to the availability of much off grade color of many types which are most easily colored dark. This is exemplified in utility black general purpose polystyrene available from primary virgin distributors which does not have rigid color or specification properties. A utility black sells for 17 cents/pound while clear or natural will sell for 18 cents/pound. Expanding on this situation even further, colored polystyrene of the "volume inventory production type", will sell for 20 cents/pound, while large quantities of special color will sell for 22 cents. The volume inventory production are single color formulations which are produced in volume economy production quantities. The processor of secondary thermoplastics and the user are a part of this total market situation. Price ranges presented in *Table 3* are an estimate of the market at time of writing.

A Note of Caution

The profit to be gained in using a lower priced raw material can be more illusory than real. In each case an analysis should be made of the economics of the situation. The most attractive situation occurs when raw material costs form a large percentage of total selling price as shown in *Table 4* and where these raw material costs can be reduced considerably with the substitution of material priced at a considerably lower level. If initial raw material costs are 50% of sales and savings of 50% of this cost can be realized, a resultant theoretical maximum saving of 25% is possible in the final cost of goods sold. However, if the profit margin is reduced because of a lower mark-up on these items, higher processing costs or a higher reject rate the economic advantage is naturally reduced. On the other side of the scale where the cost of materials is 20% of sales and the savings on material only 20%, total savings can theoretically reach a maximum of 4%. An increase in the cost of the factors of production or a decrease in selling price can actually create a situation of a net loss instead of gain here. Therefore, before secondary plastic material is to be used the following factors should be considered:

1. Potential Savings in Raw Material Costs
2. Possible increases in other production costs (e.g. cycle time, reject rate)
3. Effect on quality of merchandise.

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Conclusions

The large quantity of material sold results in a lower volume of virgin resin sales but the virgin resin supplier is able to realize a certain income from a material which may have otherwise been discarded, laid idle in storage, or reworked. If these materials are used to fabricate products which meet specifications, the ultimate consumer can benefit in obtaining a needed article at a price advantage.

Newer more efficient plants have been producing relatively less off-specification material, and molders and extruders are reprocessing more of the material themselves, but the total amount of secondary material potentially available in the market is not expected to decrease due to added resin capacity. The distribution channel may not necessarily remain the same however. Secondary plastic material offered to the processor will be consumed—at a price.

—— ■ ——

The Main Secondary Thermoplastic Sources

H. Muehlstein & Co. Inc.	Plastics Materials Inc.*
Gering Plastics Inc.	American Molding Powder
A. Schulman Inc.	Coz Chemical Corporation
George Woloch Inc.	Reed Plastics Co.*
Marine Plastics Co.	Amco Plastic Materials Inc.
M. Holland Co.	Rapid Industrial

*These companies mainly confine their activities to custom processing; this function is also carried on by most of the others however. Catalin a distributor of virgin thermoplastic material has set up a subsidiary "MaCaw" to handle off-specification material.

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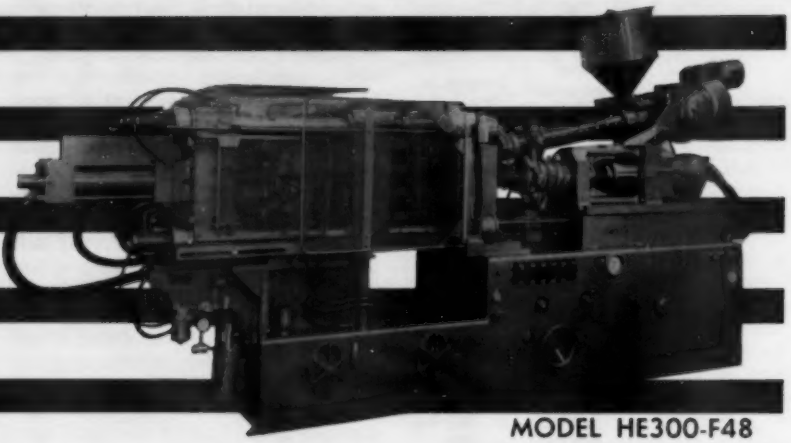

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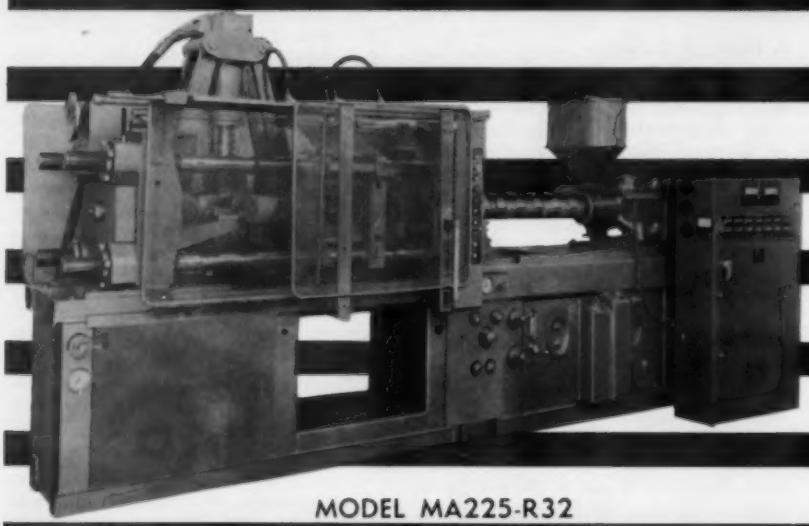

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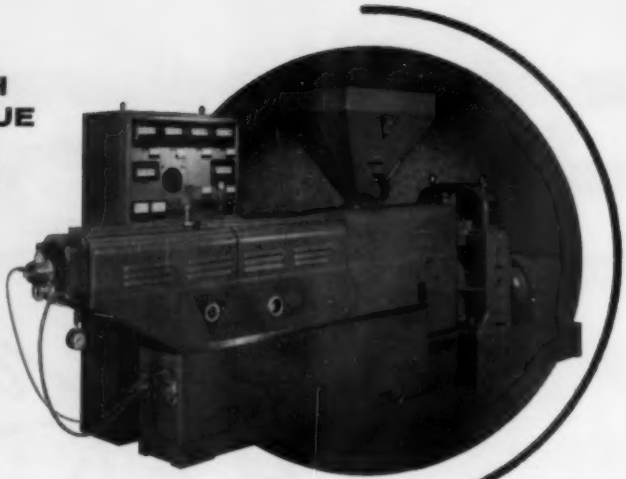

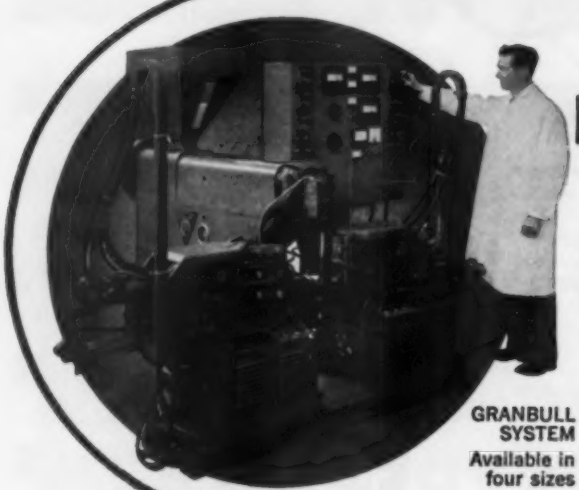

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SPEAKING OF EXTRUSION

Ram Accumulators For Blow Molding

Some problems in blow molding of large and intricate objects can be solved with the use of ram accumulators. Advantages, limitations and design requirements of this technique are reviewed in this month's column of Speaking of Extrusion

The original concept of blow molding a hollow part started with small parts for containers. It was a natural continuation of the art of blowing glass from small parisons. As blow molding has increased in scope and complexity much larger hollow parts have been under development and are being commercially produced. As a result it became necessary to find new methods of producing the parison since the old slow parison extrusion no longer would work with the large parts. Originally developed for producing large parts, the ram accumulator is gaining favor for medium size and multiple small parts production. It is the intent of this article to give some description, advantages and applications of ram accumulators designed for producing parisons that are ejected and formed at high speed.

Description

Figures 1 and 2 show the typical ram accumulator system used for producing parts ranging in weight from 20 grams to 20 pounds. The ram accumulator is quite simple in the mechanical sense and proper control of the hydraulic system which

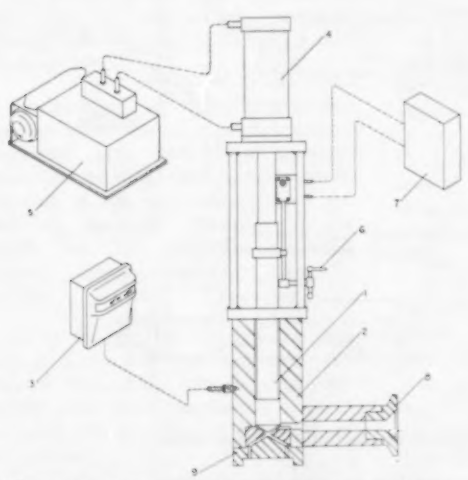


Figure 1. One pound vertical accumulator

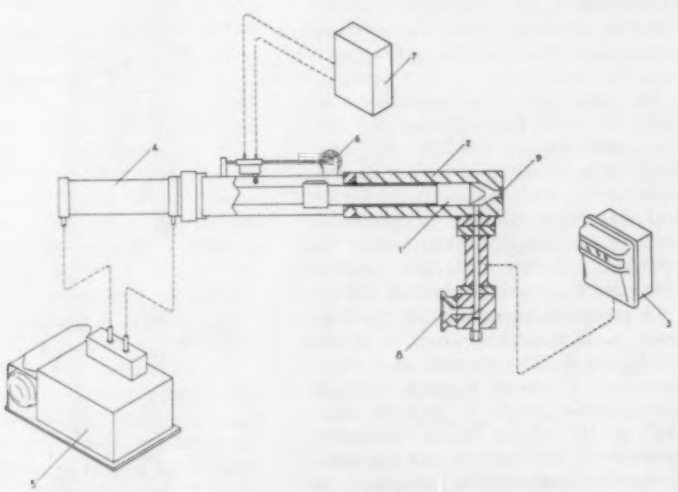
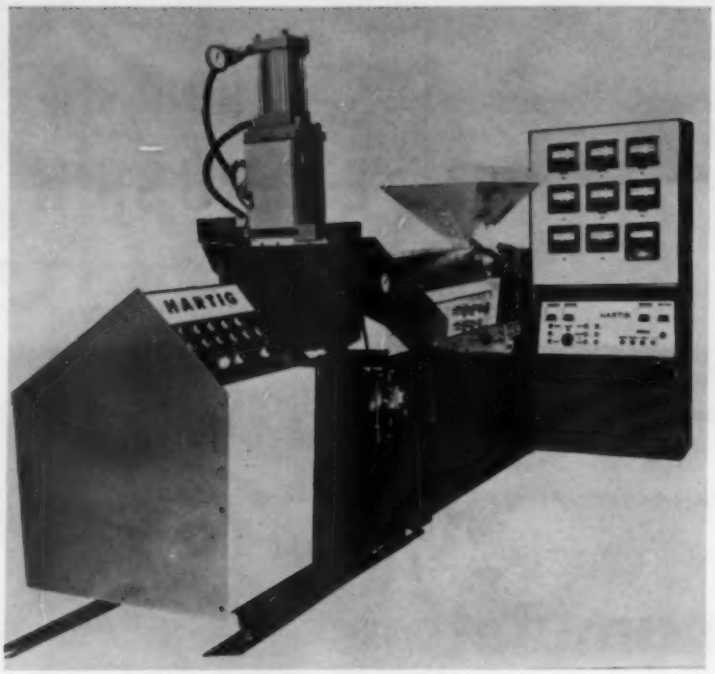


Figure 2. Five pound horizontal accumulator



drives the rams in the best manner is the more complex part of the system. The accumulator system consists of the ram (1), heated cylinder (2), Temperature control (3), hydraulic cylinder (4), hydraulic power unit (5), handle for shot size control (6), electrical control (7), connection to extruder (8), and connection to die or manifold (9). The components are similar on the small vertical accumulator (*Figure 1*) and the large horizontal accumulator (*Figure 2*). The vertical arrangement is sometimes preferred because of short connections to the die and minimum direction change of the high velocity melt flow. However, the horizontal accumulator is ideally suited to larger shot sizes because of space limitations. Furthermore, for manifold connections to multiple dies, the vertical accumulator may have no advantages over the horizontal.

No shut off valves are shown to keep the melt from flowing out the die while the accumulator is being filled by extruder. Although it is possible to use such valves, problems of leakage, valve sticking or jamming, and timing suggest that valves be avoided. Accurate hydraulic controls eliminate the need for shut off valves.

A complete blow molding package with an accumulator system is shown in *Figure 3*. This consists of a 2½" extruder, 1 pound capacity vertical accumulator, single or multiple dies, 12" x 16" platen press, hydraulic power unit and control unit for automatic operation. The diagram in *Figure 4* illustrates a larger package with a 4½" extruder, 5 pound accumulator, manifold and multiple dies and a double press with 24" x 24" platens.

Figure 3. Blow mold package with 2½" extruder, 1 pound accumulator and 8 ton single press

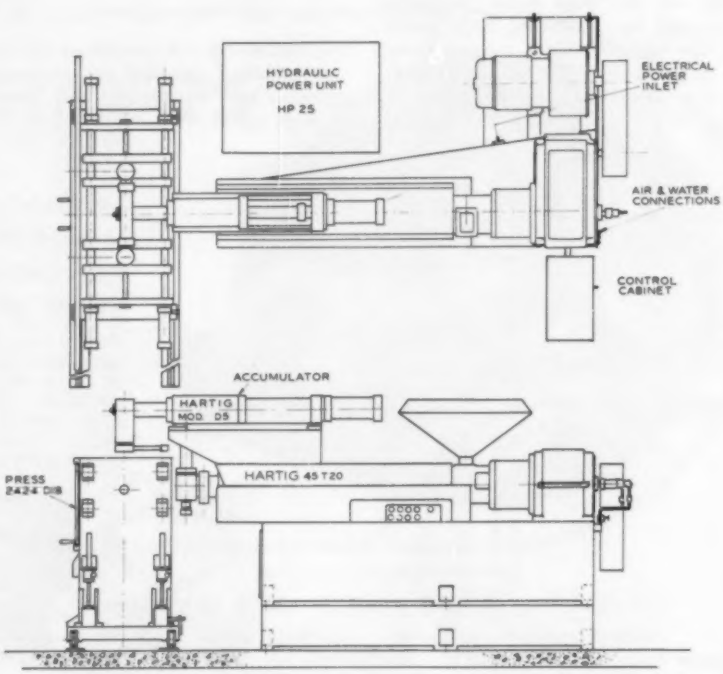
Figure 4. Blow mold package with 4½" extruder, 5 pound accumulator and 18 ton double press

It might be said that no ram accumulator can work unless the dies that form the parison are compatible with it. Much work has been done on extrusion dies and the trend has been toward the use of center fed dies which are completely symmetrical and with channels of continuously decreasing cross sectional area. In considering the ram accumulator the importance of observing fluid dynamics is emphasized. Streamlining, short passages, valving and hydraulic control all become much more severe problems when the speed of the polymer through the various parts is increased.

Advantages

1—The ram accumulator system has its greatest advantages on the very large or long parisons. A 20 pound parison would sag very rapidly under its own weight if a continuous extrusion system were used. For producing large parts with a minimum neck down and of good accuracy of size and weight it is almost an absolute necessity to use a ram type extrusion of the parison. Length of the parison sometimes has as much effect on parison sag as its weight and thin wall parisons of up to 24" long only ¾" diameter have been extruded with ram accumulators.

2—In blow molding, the excess material that must be trimmed from



the finished part represents loss of production rate and increases regrind and rehandling. It is necessary then that the parison be formed to the exact length required for molding. Accurate reproducible shot size is very easily maintained using the measured accumulator shot to form the parison.

3—Idle mold time should be considered. If a mold has ejected a part and then stands idle waiting to receive a slowly extruding parison, efficiency of the cycle is low. Almost twice as many molds will be required for a given production rate than with a system that virtually eliminates idle mold time. With a ram accumulator, the parison is shot between the molds as rapidly as the mold is emptied allowing for continuous operation. While a part is cooling, the extruder is filling the accumulator. The increased rate will also allow for producing large parts with smaller extruders. In addition, the ram can be connected to multiple dies by a manifold to produce multiple small parts.

4—Storage of the parison in the accumulator until needed eliminates the need for complicated vertical or horizontal platen motion, parison transfer, melt valving or any of the systems associated with the early systems used in blow molding.

5—Uniform temperature along the entire parison length is important in producing a uniform wall part. A parison that comes from a homogeneous storage reservoir and is extruded through the die at a great rate does not have time to be exposed to the air long enough to become uneven in temperature.

6—Rapid color change is possible with a ram accumulator because of the high velocity of the material through the die and its scouring and flushing action.

7—Because of the intermittent parison formation on a predetermined sequence and with very accurate hydraulic control, the parison cutoff, blowing of the part, retraction of the blowing mandrels, openings of the molds, etc. are simplified and the control circuit becomes relatively simple.

8—It is possible to position the ram so that a heavy section of a portion of the article can be made together with the formation of a parison and the blowing of the bulk of the article*.

* Patent Pending.

9—The melt flow through the die can be controlled* to as to modify parison size and/or wall thickness with any given die orifice. This control of parison rate ejection through a die allows the use of polymers of different melt index or density and allows, with die temperature control, as much as 50% control over part weight.

Limitations

1—High speed ejection of very small parts (less than 2 ozs.) with a single die and mold operation is not necessary. The extrusion rate is usually sufficient and cannot be significantly improved upon by ram ejection of the short light weight parison.

2—Dies that would work on continuous extrusion might malfunction when used with a ram accumulator. The ram accumulator requires better die design and calculation of the fluid dynamics of the system.

3—The ram accumulator system may require die alteration when new polymers are used because of variable parison swell due to the molecular structure of the materials that are to be extruded. Data in the ranges of high flow and the extremely high shears that these polymers must undergo with ram ejection is not always available.

4—Not all materials lend themselves to high speed ejection since melt fracture may occur at high speed extrusion rates and the ram accumulator may have to be slowed down to a point where its economic advantages are limited.

Design Requirements

1—Mechanically, the shooting cylinder must have a smooth honed bore with a tight fit on the piston, with the design suitable for retaining the fit over a wide range of temperatures.

2—The inlet port for the polymer must be designed to flush the material from the ram end at each cycle so as to avoid degradation or hang up of the material. To accomplish this, the piston should always come to the end of the stroke in the forward position and the shot size should be established by the amount of retraction.

3—The shot size should be adjustable while operating so that the exact parison length can be dialed in under continuous operating conditions.

4—The ram pressure should be adjustable to suit the die, mold and end product. Adjustment of the pressure allows some control of the weight and size of the parison with any given die orifice.

5—The alignment between the ram and the hydraulic piston rod is critical and must be very accurate and very rigid to avoid side thrust on either the hydraulic cylinder or the melt shooting cylinder. Both the hydraulic cylinder and the connection to the ram should be shielded from the heat that is required to keep the material in its plastic condition.

6—High melt pressures (up to 6000 PSI or higher) must be available to achieve the full advantage of the system.

7—A high rate of hydraulic flow must be available to provide rapid parison extrusion.

8—The dies and connecting channels must be designed for the extremely high flow rate. Conventional dies which may have been satisfactory for direct extrusion are not normally adequate for the high pressure high velocity ram accumulator type operation. Short, direct, large diameter, polished passages with minimum pressure loss and effective directional control of high viscosity materials at high flow are absolutely essential for effective ram accumulator systems. Extreme rigidity of all parts is a necessity since the high flow rates must be accompanied by high melt pressure requirements.

Typical Applications

Large thin or heavy wall containers, short heavy wall containers, toys of large size, large irregularly shaped parts such as duct work, and small parts produced in a multiple form from long small diameter parisons with a length to diameter ratio of 30:1 or more can all be produced by the use of accumulators.

Multiple parts in a single press are easily accommodated for high production rate. For instance, it is possible to produce 8 quart bottles in one press simultaneously, and with the overall time cycle controlled to a great extent by part cooling it can be seen that large outputs are possible. Half gallon and gallon containers are also well suited for this type of operation. The applications of blow molding have just scratched the surface and the hollow objects that can be produced, especially with the control possible with ram accumulators, is limited only by the designers' and producers' imagination.

Edited by
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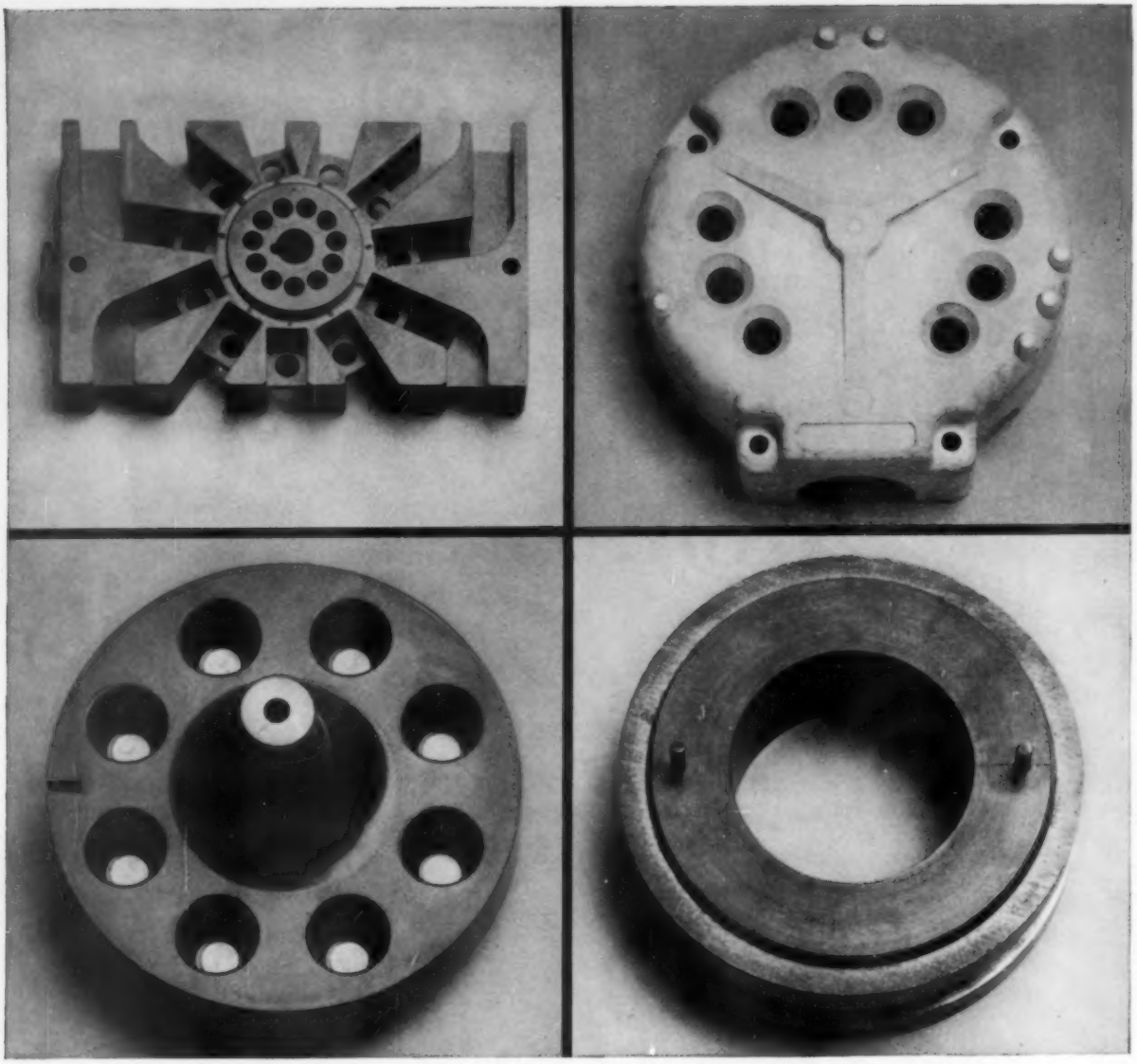

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Atlas Powder Company

REINFORCED PLASTICS

The Effects of Laminating Techniques *and* Laminate Compositions *on the Corrosion Resistance of Reinforced Polyesters*

Recent studies have shown that the method of laminate preparation is an important factor in the corrosion resistance of a reinforced plastic structure fabricated by the hand layup technique. Even when the most resistant of polyester resins is used in the manufacture of units such as hoods, tanks, ducts, scrubbers or stacks, improper laminating techniques may cause a sudden, premature end to the working life of the equipment. The equipment fabricator will find it helpful to study comparative tests, as an aid in selecting the proper resin for specific conditions and avoiding the pitfalls of poor fabrication

The structure of the laminate which depends upon the proportion of resin, type of reinforcing fiber, filler, etc. plays an important role in determining corrosion resistance. The Atlas tests show that at the end of three months laminates made up of 67% resin—33% glass outperformed 50% resin–50% glass samples in most of the corrosive solutions used.

How Laminate Structure Affects Corrosion Resistance

In addition to this superior short-term corrosion resistance shown in *Table 1*, the 67% resin test samples showed a leveling-off of flexural strength in most of the solutions (*Figure 1*). This leveling-off is of extreme importance because it results in considerably longer service life than the extrapolated short-term data would suggest. The original strength of the laminate is not important in determining the effect of resin content on corrosion resistance, rather it is the rate of deterioration. The 50/50 laminate has an initial flexural strength of 39,000 psi while that of the 67/33 laminate is 26,488 psi. The latter system shows greater retention of flex in six out of eight corrosive solutions so that the actual final strength values should eventually favor this higher resin content type. This consideration is very important from the point of view of designing a structure for corrosive service. It may be wrong to use a 50/50 glass/resin laminate just because of the initial high strength it offers because the equipment may fail shortly after being subjected to corrosive substances. Instead, a more practical action would be to: (1) increase the number of plies used in the laminate to obtain a higher original strength with a 67/33 resin/glass proportion used throughout; or (2) use a 50/50 laminate in that part of the structure that does not come into contact with the corrosive agents, and employ a 67/33 resin/glass proportion for the surface area that will contact the corrosive medium.

The superior chemical resistance of the 67% resin laminate stems from its higher resin content. Chemical inertness is imparted primarily by the resin. The glass cloth or mat is incorporated basically to add strength to the structure. Glass fiber used in these tests were of the borosilicate type, a chemically resistant type of glass generally used by fabricators of corrosion resistant reinforced plastic equipment.

Influence of Fiber Type

Corrosion resistance of a reinforced polyester structure is also influenced significantly by the type of fiber in the surfacing mat (*Figure 2*). The Atlas study showed that of the three materials tested, a Dacron surfacing mat retained the greatest degree of flexural strength in acid and equalled the performance of a glass surfacing mat in alkaline solutions, distilled water, and sodium hypochlorite. An Orlon surfacing mat proved to be inferior to both the Dacron and the glass-surface laminate in most of the corrosive solutions. Although not evaluated in this test series, Dynel has been reported to show excellent results, particularly as a surfacing mat in alkaline solutions.

How Laminate Preparation Techniques Affect Corrosion Resistance

Another phase of the Atlas study involved the effects of various methods

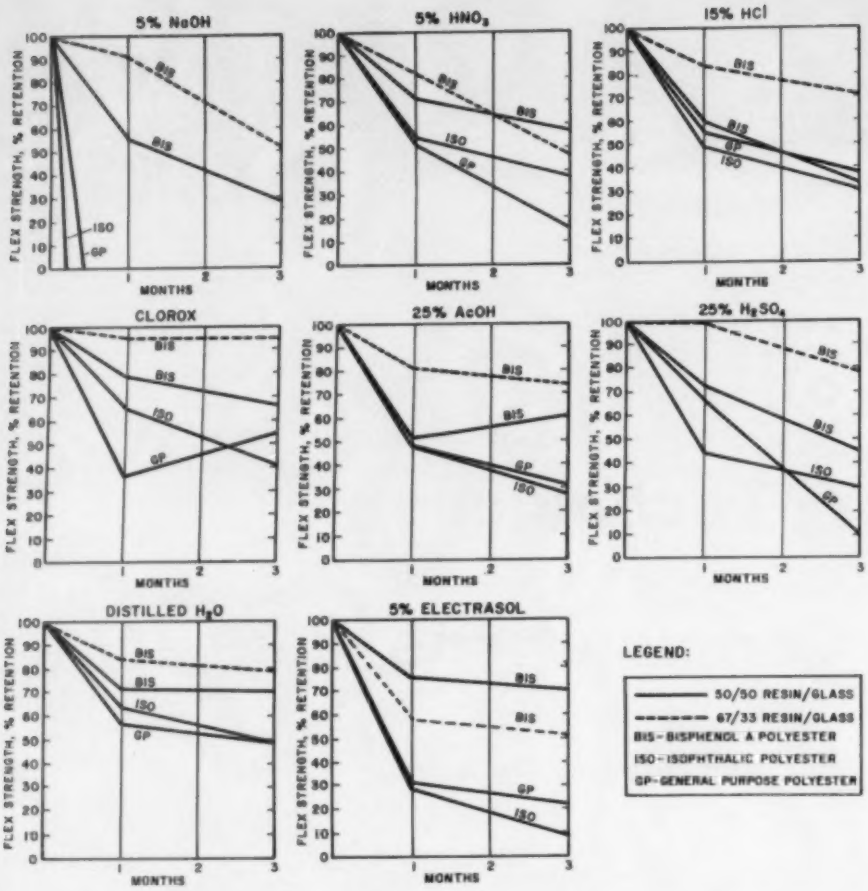


Figure 1. Flexural strength retention of hand layup laminates in corrosive solutions @ 210°F. All samples are prepared with "C" glass veil overlay and cured at room temperatures

of preparing laminates on corrosion resistance. Test samples of reinforced polyester laminates were made up in a press without the protection of a surfacing mat. The glass fiber was purposely not properly wet out, and glass fiber bundles were prominent at the surface of the structure.

The poorly wet-out, unprotected laminates showed markedly inferior corrosion resistance properties in all test solutions (*Table* 2). Although the type of polyester resin used exerts a vital influence on chemical resistance, the service life of equipment with a poorly laminated structure will be reduced to as little as one-fifth of the expected life. The test data clearly shows the importance of preparing a well wet-out laminate with a resin-rich protective surface layer to obtain maximum corrosion resistance. The most corrosion-resistant of resins will not make up for a poorly laminated structure.

Proper Laminating Techniques for Maximum Corrosion Resistance

The equipment fabricator should take positive steps to assure uniformity of laminate thickness and to hold the predetermined glass-to-resin ratio with-

Table 1. Room Temperature Cure Laminates 50/50 vs 67/33 Resin*/Glass—"C" Glass Veil 3 Months @ 210°F.

		Flexural Strength, psi	% Retention	Modulus of Elasticity x 10⁶ psi	% Retention	Barcol Hardness
Initial	50/50	39000		1.37		55-65
	67/33	26488		0.94		38-45
25% H_2SO_4	50/50	17610	45	0.94	68	32-40
	67/33	20800	78	0.91	96	47-49
5% NaOH	50/50	11080	28	0.88	64	30-37
	67/33	13900	52	0.77	81	34-41
5% Electrasol	50/50	27250	70	1.36	100	40-50
	67/33	13800	52	0.77	81	37-43
5% HNO_3	50/50	22160	57	0.98	71	45-50
	67/33	12700	47	0.70	74	39-48
25% Acetic Acid	50/50	24000	61	0.93	68	42-50
	67/33	19400	73	0.90	95	39-43
15% HCl	50/50	12930	33	0.75	55	30-38
	67/33	19000	71	0.90	95	38-40
5.25% $NaHClO_3$	50/50	26200	67	0.61	44	54-60
	67/33	25300	95	0.97	103	42-46
Distilled H_2O	50/50	27350	70	1.25	91	50-54
	67/33	20800	78	0.94	100	47-54

* Bisphenol A Polyester

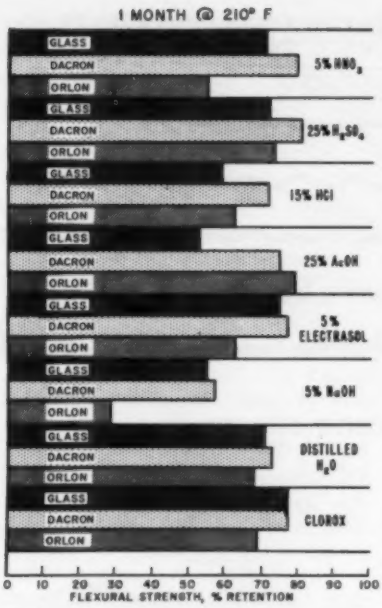


Figure 2. Effects of various surfacing fibers on corrosion resistance of laminates. Bisphenol A polyester, 50/50 resin/reinforcing fiber used in all laminates

out excessively resin-rich areas or unwet glass. The laminate should be dense, without visible voids or dry spots or a cracked or crazed surface. A minimum of air bubbles and other irregularities is a must for a well prepared laminate.

A smooth inner surface, protected by a resin-rich coating, will contribute to good chemical resistance. The outer surface should also be smooth, without exposed glass fiber bundles. All exposed glass fibers, such as those exposed by cutting of a section, must be protected by coating with resin.

Resin-Rich Layer Protects Laminate

Lay-up of a resin-rich layer on the exposed surface is the first step in preparing the surface that will be exposed to corrosive fumes or liquids. This resin rich layer is vital for protecting the reinforcing fibers within the laminate. The mold should first be covered with suitable release agent to ease removal of the past and to provide a smooth, glossy surface.

The resin used for the surface coat may contain a thixotropic agent, such as colloidal silica (Cab-O-Sil) if vertical surfaces are involved. Approximately 1 to 2 per cent of this material incorporated into the resin-styrene mix will prevent the resin from sagging or running down the surface of the mold.

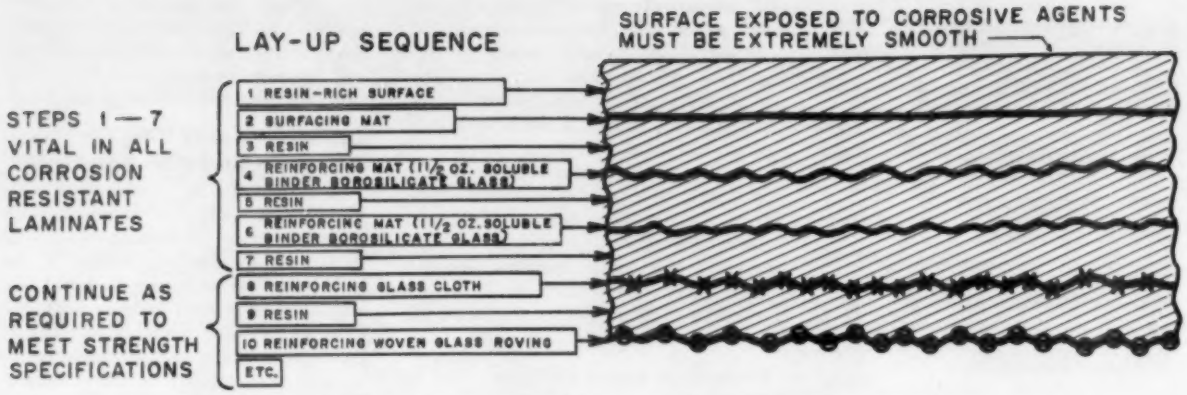
Surfacing Mat Is Vital for Maximum Corrosion Resistance

A surfacing veil or mat should be placed in the initial corrosion-resistant resin-rich layer to furnish additional protection for the remainder of the laminate. The surfacing material isolates the structural elements of the laminate. It also prevents bundles of reinforcing fibers in the laminate interior from coming to the surface. Therefore, the layer of surfacing veil or mat and resin should be smooth and without surface irregularities.

Although glass is the principal reinforcing fiber used in polyester laminates, synthetic fibers such as nylon, Dynel and Dacron may sometimes be useful as a surfacing material, particularly in applications involving fluoride fumes, which will attack glass fibers. In such an application, the synthetic-fiber surface veil will protect the glass fibers in the laminate interior. Polyester resins, particularly the bisphenol-A

Table 2. Corrosion Resistance of Poorly Wet-Out Glass-Polyester Laminates

		BISPHENOL A				GENERAL PURPOSE				ISOPHTHALIC			
		Flexural Strength (psi.)	% Retention	Modulus of Elasticity (× 10⁶ psi.)	% Retention	Flexural Strength (psi.)	% Retention	Modulus of Elasticity (× 10⁶ psi.)	% Retention	Flexural Strength (psi.)	% Retention	Modulus of Elasticity (× 10⁶ psi.)	% Retention
INITIAL		26460		0.98		26210		1.09		29249		1.07	
						AT ROOM TEMPERATURE							
25% H_2SO_4	1 wk	19900	75	0.85	86	21958	83	0.92	84	25440	86	1.08	100
	1 mo	16600	62	0.71	72	15900	60	0.74	67	20800	71	0.96	89
	3 mos	16100	60	0.63	64	17020	64	0.68	62	18130	61	0.78	72
5% NaOH	1 wk	15300	57	0.90	91	14448	55	0.77	70	19882	67	0.98	91
	1 mo	11300	42	0.87	88	6300	24	0.58	53	12400	42	0.93	86
	3 mos	13150	49	0.75	76	0	0	0	0	6000	20	0.77	71
Distilled H_2O	1 wk	22300	84	0.96	94	19637	74	0.85	77	24414	83	1.04	97
	1 mo	20200	76	1.02	104	21198	80	0.90	82	23000	78	1.10	102
	3 mos	20100	75	0.95	96	20330	77	0.92	84	21710	74	1.01	94
						210°F. EXPOSURE							
25% H_2SO_4	1 wk	12906	48	0.81	82	4581	17	0.21	19	13059	44	0.59	55
	1 mo	5800	21	0.37	37	410	1.5	—	0	5800	19	0.48	44
	3 mos	3100	11	0.42	42	507	2.0	—	0	3100	10	0.40	42
5% NaOH	1 wk	15218	57	0.79	80	deteriorated in less than 1 wk.				deteriorated in less than 2 wks.			
	1 mo	9650	36	0.79	80	0	0	0	0	0	0	0	0
	3 mos	4200	15	0.65	66	0	0	0	0	0	0	0	0
Distilled H_2O	1 wk	15900	60	0.82	83	12995	60	0.65	59	19678	67	0.95	88
	1 mo	11600	43	0.74	75	6149	23	0.46	42	13000	44	0.86	80
	3 mos	8750	33	0.68	69	4300	16	0.37	33	8200	28	0.72	67


LAY-UP SEQUENCE
SURFACE EXPOSED TO CORROSIVE AGENTS MUST BE EXTREMELY SMOOTH
STEPS 1 — 7 VITAL IN ALL CORROSION RESISTANT LAMINATES
CONTINUE AS REQUIRED TO MEET STRENGTH SPECIFICATIONS
1 RESIN-RICH SURFACE
2 SURFACING MAT
3 RESIN
4 REINFORCING MAT (1 1/2 OZ. SOLUBLE BINDER BOROSILICATE GLASS)
5 RESIN
6 REINFORCING MAT (1 1/2 OZ. SOLUBLE BINDER BOROSILICATE GLASS)
7 RESIN
8 REINFORCING GLASS CLOTH
9 RESIN
10 REINFORCING WOVEN GLASS ROVING
ETC.

PROPER LAMINATE CONSTRUCTION FOR CORROSIVE SERVICE

type, will resist attack by fluorides under certain conditions.

The surface veil appears to contribute more to overall structural strength than might be expected. This factor should be considered when designing laminates containing synthetic-fiber surfacing mats, which are lower in strength than similar laminates containing glass.

Interior Laminate Construction

The resin rich layer and surfacing mat should be followed by two alternate layers of chopped strand borosilicate glass reinforcing mat and resin (refer to box on this page) (*Figure 5*). Mat weight should be at least 1-½ oz. The binder in the mat should be resin-soluble to allow the glass mat to be formed without springback.

Subsequent layers of glass mat, cloth, or woven roving may be added to satisfy weight and strength requirements of the specification.

Uniform Distribution of Resin Is Necessary

The resin applied to the various layers of reinforcing mat or cloth must be distributed evenly. The resin is usually spread by brush or roller over and into the reinforcing material. However, some fabricators are now turning to spraying because it offers greater speed and reduces labor costs.

The resin is distributed on and into the mat by a metal, plastic, or cloth-covered roller. Proper rolling will contribute to thoroughly wet-out fibers, without pin holes in the resin surface, and deep resin penetration in overlapping areas. Rolling also eliminates the great volume of air present in the mat.

Overlapping areas of mat or cloth require special care to cover each layer with resin individually. While a poorly constructed overlapping section will weaken the entire structure and diminish corrosion resistance, a proper joint will enhance the working life of the laminate. For cloth or mat, an overlap of at least ½-in. is recommended. Lapped sections of adjacent layers should be staggered for maximum strength. The recommended fabricating technique involves peeling back the upper layer and thoroughly covering and rolling the area beneath. The overlapping section is then replaced over the lower layer, which contains a surplus amount of resin. Brushing or spraying resin and rolling the upper layer completes formation of the joint.

The Effect of Curing Methods

Method of curing the resin will exert a definite influence on both the strength of the laminate and its corrosion resistance. The amount of catalyst used is one of the most important considerations. Catalyst content, which should be based on the thickness of the section being fabricated, will affect the gel time and storage life in the pots.

The catalyst functions basically to begin the exothermic reaction. A thin section requires more catalyst because of rapid heat losses through convection and radiation. Thick sections, on the other hand, generally need less catalyst because a much higher exothermic temperature is developed in the structure.

An excessive amount of catalyst should be avoided because it causes too rapid a cure, with resulting internal stresses. Surface cracking (crazing) is prime evidence that internal stresses have been set up by excessive exotherm. These cracks, caused by unequal expansion of the surface and interior of the laminate, will allow the entrance of corrosive fumes or liquids and will hasten deterioration.

How to Check for Laminate Quality

Visual examination provides one of the most simple and effective ways to judge the soundness of a laminate. By placing a light behind the wall or section of an unpigmented structure, the fabricator can judge the uniformity of the laminate and detect air bubbles, dry spots, internal cracking or other conditions indicating possible weaknesses in the structure.

Surface condition is another indication of laminate construction. A smooth, true surface is generally a sign of a well-made uniformly-cured laminate. If exposed fibers exist on the surface, there is a rupture in the protective gel coat vital to corrosion-resistance. Exposed fibers bundles also indicate the likelihood that a surfacing mat is absent.

Industrial specifications will often call for cutting a section of the fabricated piece (overage of length, manhole, etc.) for testing. The resulting cross section will reveal the depth of the surface layer and shape and conformity of the laminate. Stressed areas often will be seen immediately in the form of internal cracks. The cross section will also show the bond between layers and degree of wet-out of the fibers as well as the position of the surfacing mat and the thickness of the protective resin-rich layer.

Another test often used is Barcol hardness. This test is useful only for measuring the relative hardness of pieces fabricated from a single type of resin. Results are meaningless when comparing different resins because each polyester resin will have its own inherent hardness. If the Barcol hardness of a laminate falls short of the average ratings found in well-cured structures of the same resin and construction, the fabricator should immediately suspect an incomplete cure, which results in poor corrosion resistance.

—— ■ ——

edited by **George Lubin,**
Grumman Aircraft Engineering Corporation

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Hetron® for outboard motor shrouds**
- **Plastic potentiometer**
- **Dip-coating compounds**

Great for waterways

One key advantage of Hetron polyester resins is durability under stress. This quality turns out to be particularly pertinent for Gale Products, a division of Outboard Marine Corporation.

In the outboard motors produced by this Illinois firm, shroud permanency was a problem. The solution was to make them of Hetron reinforced with fibrous glass. A critical step in the production process consists of two baking operations at 240°F. The material takes the bakes without crazing.

In use the shrouds won't crack,

GALE PRODUCTS

craze, or corrode. They resist denting and abrasion, have high impact strength, are lighter than metal covers (about 3 lbs. lighter in the case of a 50-hp motor), protect motor parts from water spray, are about 15% less expensive to produce than metal covers.

An additional benefit is the transformation of the motor's roar to a pleasant purr, which permits boaters to enjoy conversation with their sport.

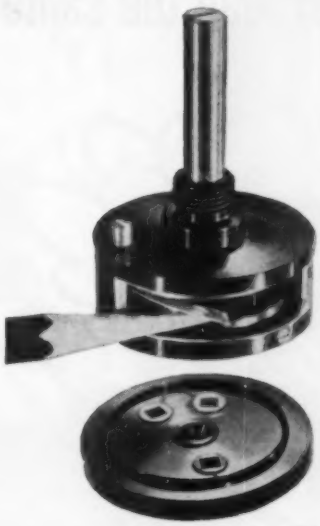
Hetron resins have properties that make for superior performance in a wide variety of applications. We'll be happy to send you detailed information on this family of premium polyesters.

Look—no coils

Get to the heart of a new and better product, and often you'll find a Durez plastic.

For instance: this little precision potentiometer. It's better because it's simpler—contains no resistance wire, no varnish, no cement to come unstuck and cause failure.

Instead, the metallic wiper (at pencil point) rides on an almost friction-free plastic ring, the resistance element. The



NEW ENGLAND INSTRUMENT CO.

ring is made of diallyl phthalate resin mixed with carbon. The buttonlike insulating base is a standard Durez diallyl phthalate molding compound.

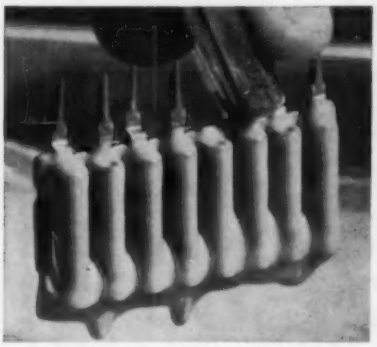
Potentiometers made with these materials just don't seem to wear out. Nor do they lose their excellent insulation properties in clammy surroundings. For these reasons, the little instruments are being specified widely for missile and rocket control systems, computers, and servo gear.

When your design project needs a moldable material of far-better-than-average electrical properties—*plus* resistance to moisture and heat—think of Durez diallyl phthalate molding compounds. We'll gladly send you facts about them.

Coat for components

Looking for a simple encapsulating idea? Here's one that works well at heatproofing, moistureproofing, and preventing shorts in small electrical components. It's non-messy, too.

Dunked in a paste coating, dried, then baked for a short time, components steadfastly resist extremes of heat and moisture that would otherwise raise havoc with their electrical reliability.



Components so coated can be soldered into a circuit without causing the coating to melt or peel. It won't soften, and easily passes a series of −55 to +85°C cycles. One thousand hours at a sweltering 150°C will turn the coating almost black, but still won't materially affect the component inside.

The paste is made with Durez phenolic resin-and-filler compounds supplied in powder form. After baking, it is impervious to ketone solvent cements sometimes used in assembling radio and TV chassis.

What can these dip-coating compounds do for you? We'd like to help you find out. Write for more detailed information.

For more information on Durez materials mentioned above, check here:

- ☐ Bulletin D-6: properties and applications of Hetron fire-retardant resins
- ☐ Data sheets: facts about diallyl phthalate molding compounds
- ☐ Data on phenolic resin compounds for dip-coating

Check, clip and mail to us with your name, title, company address.

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HOUSEWARES—These tumblers and cups, injection-molded by Fedco, stand up to any scalding dishwasher temperature, even boiling water and steam sterilization. BAKELITE high-density polyethylene helps make it possible. They're comfortable to handle because of an insulating air space between their double walls.

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APPLIANCES—When critical points of strain and wear are involved, appliance makers have turned to BAKELITE high-density polyethylene. This gusset for a major brand refrigerator is a case in point. Toughness plus rigidity—at different temperatures—are a specialized demand, but a job high-density polyethylene does well.

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CHARACTERISTICS	HOMOPOLYMERS				COPOLYMERS	
					For toughness, stress-cracking resistance, flex life	
	DMD-6201	DMD-7004	DMD-7014	DMD-7000	DPD-7070	DMD-7002
Description	High Flow General Purpose	High Rigidity	7004 Equiv. With Improved Weathering	7004 Equiv. With Higher Flow	High Rigidity	Extra High Rigidity
Density, gm/cc	0.950	0.960	0.960	0.960	0.945	0.950
Melt Index, gm/10 min.	8.0	3.5	3.5	5.0	8.0	7.5
Secant Modulus psi (stiffness)	100,000	150,000	150,000	150,000	70,000	100,000
MECHANICAL						
Tensile Strength, psi	3,300	4,700	4,700	4,600	2,250	3,200
Ultimate Elongation, %	45	30	30	15	25	25
CHEMICAL						
Water Absorption, %	0.03	0.03	0.03	0.03	0.04	0.03

Looking for fresh avenues to bigger profits? Take a good, close look at what's happening in many markets now capitalizing on the outstanding benefits of injection-molded high-density polyethylenes.

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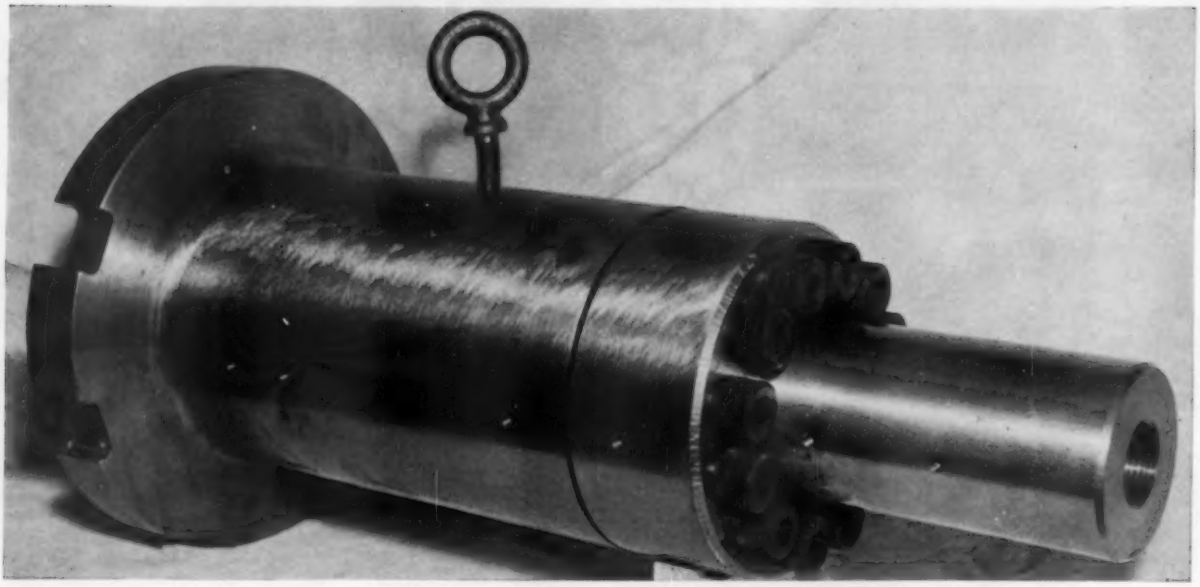

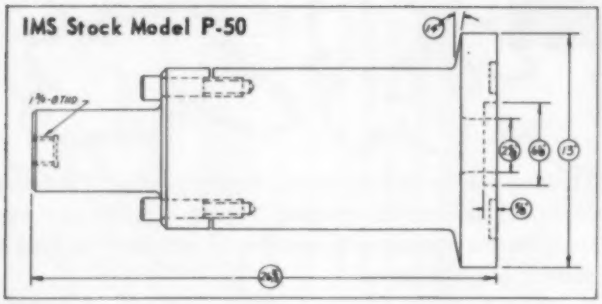

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Extra for chrome plate.....$290.00
Price includes bands but no nozzle, cover or wiring.

Specify flange taper - 14° or 24°.
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We have been conservative in making claims for VRF Heater performance as we are heating cylinder engineers, NOT promoters. In the heating cylinder business, we take the long term viewpoint. We can't afford to use an idea like VRF just to make "hit and run sales" because IMS Heating Cylinders, like other IMS Products must be measured by years of your satisfaction.

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MOLDING CYCLES

Encapsulation Through Molding

Injection molding offers an ideal way to produce the molds needed for casting and encapsulation

The rapid development of applications for encapsulation using liquid resins as well as molding compounds has brought about a need for new techniques in processing. The basic problem in the use of casting resins is cure time. Rapidly gelling mixes create the hazard of short pot life while long gel times create a requirement for large numbers of molds. Opposed to these conditions is the difficulty of holding the parts to be encapsulated when high pressure molding is used. Even the so-called "low-pressure" compounds pose problems in seal-off and support of inserts.

The solution of these problems is not simple since each application is usually unique in itself. A method of approach is evolving which may prove to be a boon to the custom molder. This method utilizes the molding press as a means of producing molds in sufficient quantity to justify the use of long pot-life systems. While it is not a cure-all it does offer many possibilities to the molder who can use some ingenuity in mold design and who is willing to engineer his jobs to the fullest extent.

Rules to follow

Casting resins, particularly the epoxies, are available in so many different combinations it is sometimes difficult for even an experienced processor to decide which one to use for a specific application. A few rules will help in making that decision:

1. The application must be classified as to property requirement.
2. The properties that are most important must be identified and established as minimum specifications.
3. The intricacy of encapsulation must be carefully studied to determine how difficult the elimination of leaks of resin will be and just what problems of air entrapment must be solved.
4. The thickness of the cast product may create a problem in exotherm, dictating the need for either controlled cooling or successive pourings rather than a single one.
5. The problem of release is ever present. Consideration of cost of removing the finished product must be thorough since it may be more practical to use expendable molds and forget about release.
6. The design of the finished product must not be delegated to the customer alone. The molder must assume his place on the team of design to guide his customer away from cost traps and impractical ideas.
7. The application for which the finished product is intended should be investigated wherever possible to make certain all of the information necessary for a resin selection is available.

As a general rule, fast curing systems will produce high exotherms and sacrifice properties of the resin. The cross linking produced by rapid polymerization is normally not complete so that the maximum quality of product is not obtained. By using the molded-mold technique it is possible to utilize slow curing systems and gain the benefits of full cross linking.

Case Histories

A typical example of the use of molded components to provide molds for encapsulation is a connector assembly used in electrical distribution systems on naval vessels. Basically this unit is an arrangement of AN type connectors which are wired together inside a housing and then sealed hermetically through the use of an epoxy system. Rather than attempt to cast a block of epoxy which would encapsulate the connectors

and require very expensive molds with the additional problem of secondary operations, the housing was designed as a two-piece assembly, the two pieces being identical. An injection mold for the housing halves was built, incorporating all of the details necessary for holding the connectors in place during encapsulation. By preparing the internal surfaces of the housing it was possible to bond the epoxy to the housing and thus hermetically seal all wiring and yet produce a clean, compact and practical unit which met all of the requirements and in addition had a truly professional appearance.

The problem of sealing the housing halves to avoid leakage of resin was the most difficult part of the job. The connectors, through their very shape, did not afford an easy means of sealing. To solve the problem, a sealing compound was applied to all joints and then removed after the resin was gelled.

Since the resin had to be injected into the housings without an entrapment of air it was necessary to make certain all air was removed before the resin completely filled the housing. Vacuum could not be used conveniently since the connector terminals were sealed against only a very small pressure and air leaks were possible. It was decided that a pouring riser similar to that used in casting metals would be used and a sight tube was inserted in the housing to indicate the level of fill. The riser was molded of polyethylene and was large enough to contain the entire charge of resin needed to fill the housing. A one-cavity automatic mold was used to mold the risers and extruded tubing served as sight tubes. It is interesting to note that the reject rate of this job was just short of phenomenal. Not a single unit in an order of many hundreds was rejected for any reason, electrical, mechanical, or visual. The previously used techniques yielded a reject rate of more than 25%.

A second example of the molded-mold method, while not as detailed, yielded a product that opened the door to a series of products in the same field. One of the very first applications of encapsulation, originally called potting, was that of the television fly-back transformer. Since that early start using polyester resins the number of electronic potting applications has increased at a remarkable rate. Departing from the usual methods of potting in a mold and then removing the finished product, this second example, an electronic filter, was cast in a polyethylene housing so that the attractive appearance of the housing was utilized. This led to the redesign of a number of products in the same general field with the housings serving as the assembly fixture and mold. The reduction in cost was outstanding.

The use of molded-molds permits the production of large volumes of potted assemblies since the need for multiple cavity casting molds is eliminated. Slow curing systems can be used since the molds do not have to be reused. Maximum quality is thus obtainable since long pot life permits the use of more time in casting. The resin mix can be de-aerated without the fear of sudden gelation, and the pouring process can be made a step-wise precedure, providing for proper release of air.

The custom molder, traditionally bound to the use of pressure to create a finished product, can readily add the facilities needed for casting at a relatively low cost. Injection molding offers an ideal way of producing the molds needed for casting and more specifically encapsulation, although compression and transfer molding can also serve well. The cost of a single cavity injection mold plus one thousand parts has proven to be lower than the cost of a multiple of molds for casting which must be stripped and cleaned after each pouring. In those cases where the cure time at room temperature is four or more hours, the turnover of molds is less than twice per shift and the cost of casting at any reasonable production level becomes prohibitive. With molded-molds, the cost of long cure is offset by the number of cavities than can be poured at one time.

The electronics industry has been the principle market for encapsulated products. Many other industries could very well use the benefits of not only encapsulation but casting as a basic process if the techniques of mold production were improved and the cost of casting reduced through the use of not just a few molds but possibly tens or hundreds of molds. The custom molder has the facilities required for the production of casting molds. A bit of ingenuity, native to most molders, plus a large amount of curiosity with a touch of basic mold design will provide the means for conquering the new fields the molder always seeks.

Acknowledgment

The author wishes to thank Mr. Max Hilrich for his assistance in evaluating the curing systems of the epoxy resins used.

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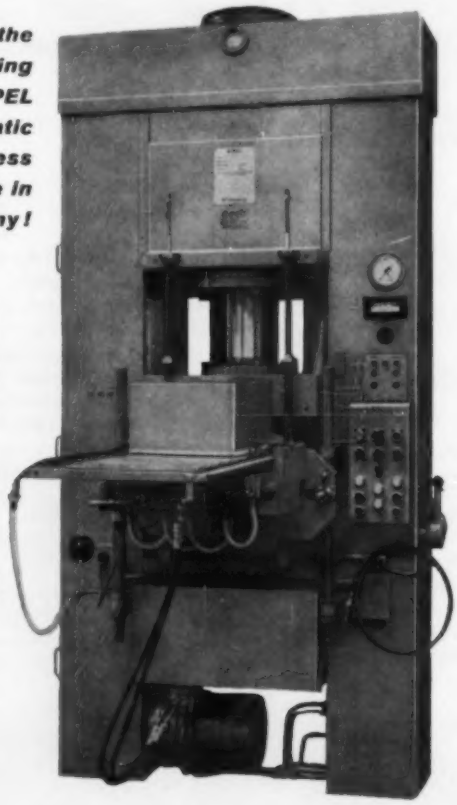

INSTRUMENT HOUSING—Made of MARLEX, it's lighter and more durable, resists cracking and warping . . . for "Plug-Scope," spark plug tester manufactured for Champion Spark Plug Company by Heyer Industries, Incorporated. Molded by Fibro Corp., Clark, N. J.

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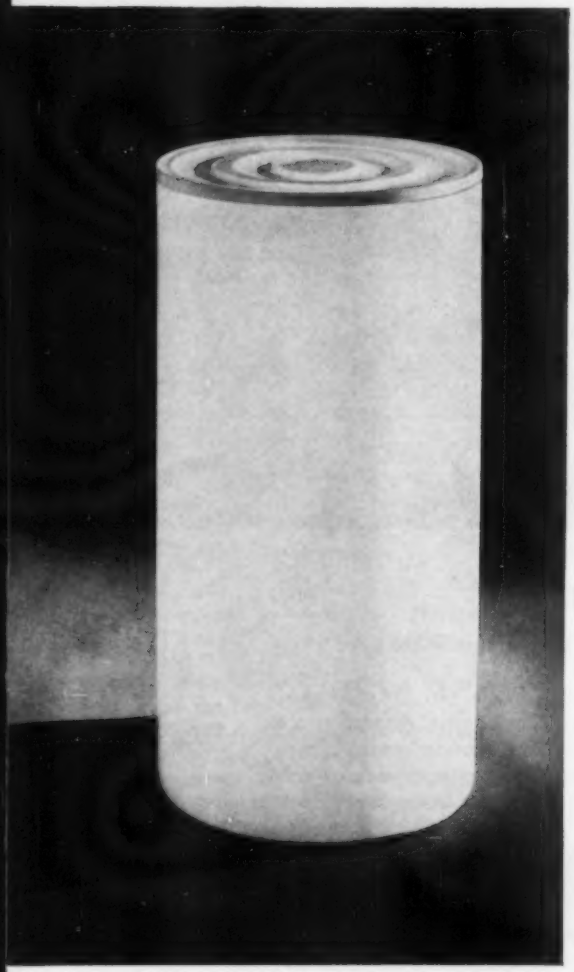

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A new linear polyester having superior electrical properties, excellent hydrolytic stability, as well as good strength and toughness is described. Properties of this film are compared with those of poly(ethylene terephthalate) film.

Properties of a New Polyester Film

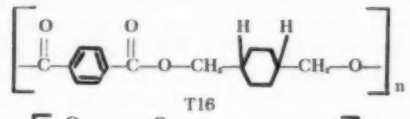
M. T. Watson

Tennessee Eastman Co. Research Laboratories
Division of Eastman Kodak Co.

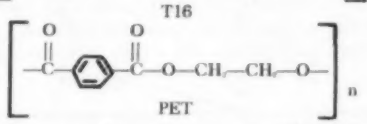
High-molecular weight polymers prepared by condensation of terephthalic acid and 1,4-cyclohexanedimethanol are especially advantageous for the formation of fibers and films (1). The linear polyester so produced, poly(1,4-cyclohexylenedimethylene terephthalate), is the polymer from which Eastman's Kodel* fiber is made (2). It is the purpose of this article to describe properties of thin films of such a polyester.**

Structure

The repeat unit in the chain of poly(1,4-cyclohexylenedimethylene terephthalate), hereafter designated as T16, is shown below, compared with that of another well-known polyester, poly(ethylene terephthalate), designated as PET (3, 4).



T16



PET

The most obvious structural difference between the two polyesters is the presence in the repeat unit of T16 of a cyclohexane ring between the two methylene groups. As a consequence, there are significant differences in the properties of the two polyesters; for example, T16 melts at 260-290°C., depending on the exact formulation, which is some 5-35°C. higher than the melting point of PET. Solution properties indicate a stiffer molecular chain in T16 (5). The tendency of T16 to hydrolyze is greatly suppressed by the presence of cyclohexane rings in the chain. Accordingly, it has outstanding resistance to hot, humid conditions—an important asset.

Film Processing

For processing into film, T16 is polymerized to a weight-average molecular weight of around 25,000. The polymer, in the form of pellets, is melt-extruded at about 300°C. through a slot die onto a polished drum to form an amorphous sheet. At this stage, the sheet is clear and tough: tensile strength is more the 8,000 psi., tensile modulus is more than 2 x 10^5 psi., elongation at break is more than 200%, and tear strength is high. The heat-distortion temperature is only about 90°C., however, and the film is not especially useful because heating it above this temperature for some time causes crystallization to occur. When this happens, the film becomes rather brittle, and unless it is very thin, it turns opaque and white. It is therefore advantageous to heat the amorphous film and stretch it lengthwise and widthwise to two or three times its original dimensions.

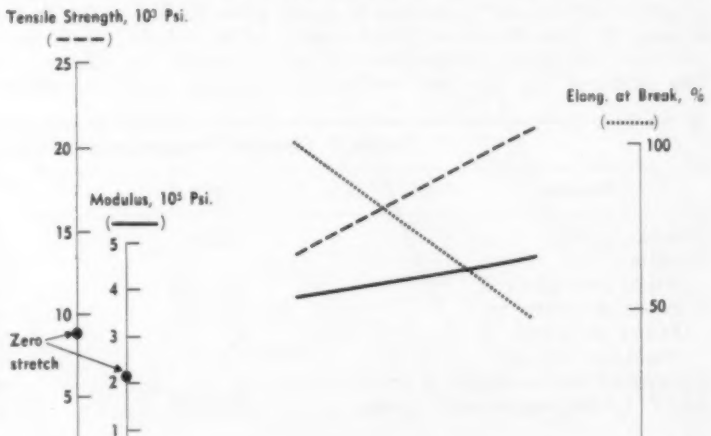


Figure 1. Tensile properties of T16 film as a function of amount of stretch. Tensile strength and modulus increase but elongation decreases with increasing orientation (amount of stretch).

* Registered trade-mark, Eastman Kodak Company.
** Films commercially available from Acme Backing Corp.

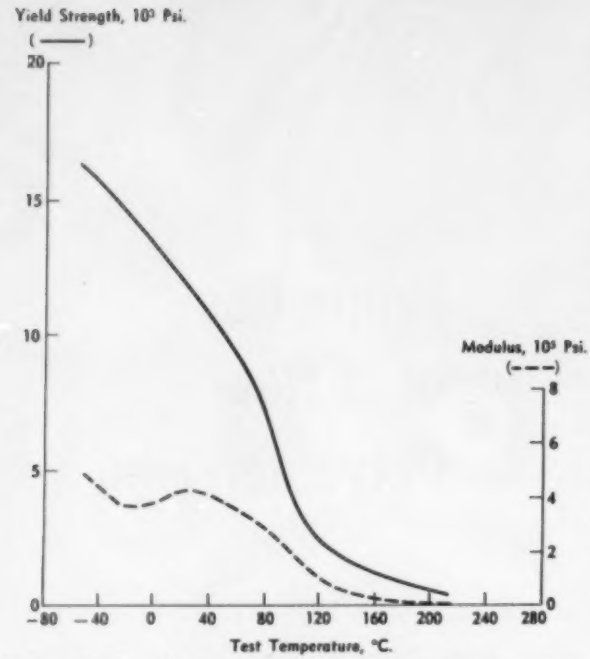


Figure 2. Tensile properties of T16 film as a function of temperature. Modulus curve shows two slope changes. Yield strength decreases monotonically.

When done under the proper conditions, this treatment results in random orientation of the molecular chain directions in the plane of the film. Mechanical properties are enhanced in both directions. If a restrained high-temperature heat-setting is then given to the film to effect crystallization, the resulting film is clear, strong, tough, and thermally stable against deformation up to temperatures near that at which the crystallization was carried out. In contrast to the unoriented film, oriented film when crystallized does not become brittle or opaque.

Film Properties

Mechanical Properties—The extent of improvement in film properties depends on the amount of stretch given the film. If about the same amount of stretch is achieved in each direction, at the proper temperature and rate of stretch, the film produced has the same mechanical properties both lengthwise and widthwise. Thus, a single value for a given property, irrespective of test direction, can be quoted for such film. Accordingly, *Figure 1* gives a plot of tensile strength, modulus, and elongation versus amount of stretch for biaxially-stretched and crystallized film. Tensile strength increases markedly and modulus slightly with increasing orientation, but elongation decreases. Tear strength, which is not plotted in the figure, also decreases with increasing orientation. Heat-distortion temperature, using a fixed heat-setting temperature to effect crystallization, decreases with increasing orientation; evidently, crystallite formation becomes more difficult as potential crystallite sites are pulled away from one another by increasing molecular orientation. A decrease in heat-distortion temperature occasioned by increased orientation can be compensated for, however, by use of an additional short-time high-temperature annealing treatment, without appreciably altering mechanical properties.

The physical properties of T16 film biaxially stretched about 200% and heat-set are compared with those of PET film in *Table 1*. Both films were 0.5 mil thick. T16 film has a lower density than PET, a distinct advantage for T16 since a given weight of resin will produce more film of a given thickness. On the other hand, PET film is stiffer, stronger, and tougher than T16 film. A rough calculation based on the densities of the two films can be made. Assuming that the intermolecular attraction energy is inversely proportional to the sixth power of the distance between molecules (8), the 13% higher density of PET leads to a prediction of about 50% higher intermolecular forces in this polymer than in T16, assuming about the same molecular weight and orientation in the two. This is roughly the factor by which modulus, yield strength, and break strength of PET are higher than those of T16. Thus to a rather crude first approximation, it appears that the higher strength and toughness of PET can be accounted for by its higher density. It should be pointed out that the strength and toughness properties of T16, although lower than those of PET, are adequate for most end uses and are in fact better than those of many other commercial films.

T16 has better color than PET, an advantage that is particularly apparent in vacuum-metalized film applications. Because of its higher melting point, T16 is inherently capable of yielding film having a higher heat-distortion temperature. The heat-distortion temperature attained for any given film is of course strongly dependent on processing conditions. T16 film has low moisture absorption; its value is lower than that of PET film.

Table 1. Physical Properties of 0.5-Mil Polyester Films

Property	T16	PET	Test Method
Density, g./cc.	1.226	1.390	ASTM D1505-57T (6)
Tensile			ASTM D882-56T (6)
Yield strength, psi.	10,000	14,000	
Break strength, psi.	17,000	26,000	
Elong. at break, %	45	105	
Modulus, 10^5 psi.	4.0	6.8	
Elmendorf tear strength, g./mil	6	18	ASTM D689-44 (6)
M.I.T. folding endurance, cycles	>60,000	>60,000	ASTM D643-43 Method B (6)
Mullen burst strength, psi.	28	37	ASTM D774-46 (6)
2% Heat-distortion temp. under 50 psi. initial stress, °C.	165	158	Ref. 7
Water absorption (24-hr. immersion, room temp.), %	0.30	0.55	ASTM D570-57T (6)
Soluble matter lost (24-hr. immersion, room temp.)	None	None	ASTM D570-57T (6)
Color	Water-white	Slightly yellow	—

Table 2. Low-Temperature Tensile Properties of T16 Films

	Film Thickness, Mils					
	0.5		1.0		2.0	
Testing temp., °C.	−25	−50	−25	−50	−25	−50
Yield strength, psi.	14,800	15,800	14,100	15,500	13,600	18,500
Break strength, psi.	21,800	22,600	20,200	20,700	22,200	25,300
Modulus, 10^5 psi.	4.4	4.8	4.1	4.6	4.4	4.5
Elong. at break, %	38	32	45	43	50	35

The tensile modulus and yield strength of 1.5-mil, fully processed T16 film measured over a range of temperatures are plotted in *Figure 2*. The modulus curve shows two slope changes, one in the vicinity of −40°C. and the other in the vicinity of +100°C. Yield strength decreases monotonically over the entire temperature range.

Low-temperature tensile properties of T16 films of several thicknesses are listed in *Table 2*. These results indicate no evidence of brittleness down to −50°C.

Heat-Sealability—Because of the tendency of T16 film to disorient at the high heat-sealing temperatures it requires, it is difficult to heat-seal on ordinary equipment. However, the film can be readily heat-sealed on impulse-type heat-sealing equipment.

Stability—Data showing thermal, oxidative, and weathering stabilities of T16 and PET films are given in *Table 3*. The two polyesters have comparable thermal stabilities, indicating that the amount of degradation occurring during melt extrusion, in which oxygen is excluded from the plastic melt, should be about the same for the two, at least at the same extrusion temperature. The lower oxidative stability of T16 is not unexpected in view of the presence in the molecule of two tertiary carbon atoms per repeat unit; PET has none. In low-molecular-weight compounds—for example, hydrocarbons (9)—tertiary carbon atoms are known to be more susceptible to oxidative attack than secondary carbon atoms. Oxidative stability of T16 films can be greatly improved, however, by inclusion of a suitable stabilizer, as discussed below. Weathering stability is about the same for both polyesters; neither is a really weather-resistant film.

Results of Massachusetts Institute of Technology (M.I.T.) folding endurance tests [ASTM D643-43, Method B (6)] on films after heat-aging at 160°C. in air are shown in *Figure 3*. T16 film containing no stabilizer embrittles much more rapidly than PET film, as expected from the oxidative stability results in *Table 3*. T16 film containing a suitable stabilizer, however, is still highly flexible after aging for 32 days.

In hydrolytic stability, i.e., resistance to degradation under hot, humid conditions, T16 is clearly superior to PET, as shown in *Figure 4*. This figure gives a plot of retention of inherent viscosity, which is a measure of molecular weight, as a function of exposure time at 110°C. and 100% relative humidity.

As an illustration of an end-use in which the film might have to withstand elevated temperatures in the presence of moisture, we prepared 0.01-μf. capacitors from 0.5-mil PET and T16 films, leaving the outer polyester film layer bare.

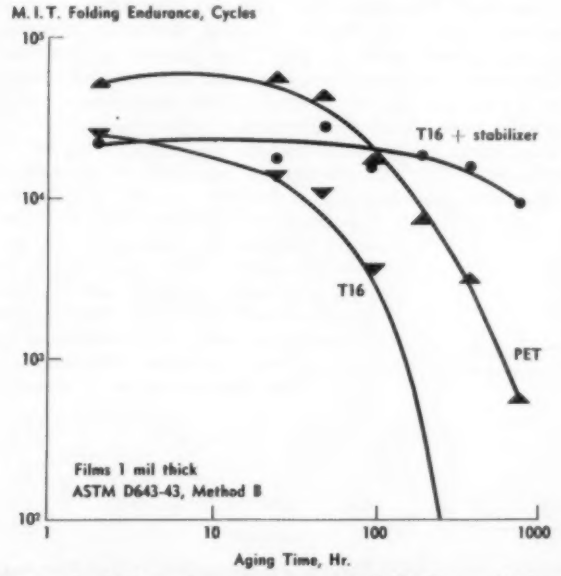


Figure 3. Effect of aging in air at 160°C. on folding endurance of polyester films. Unstabilized T16 film embrittles more rapidly than PET film, but T16 film containing a stabilizer remains highly flexible after 32 days' aging.

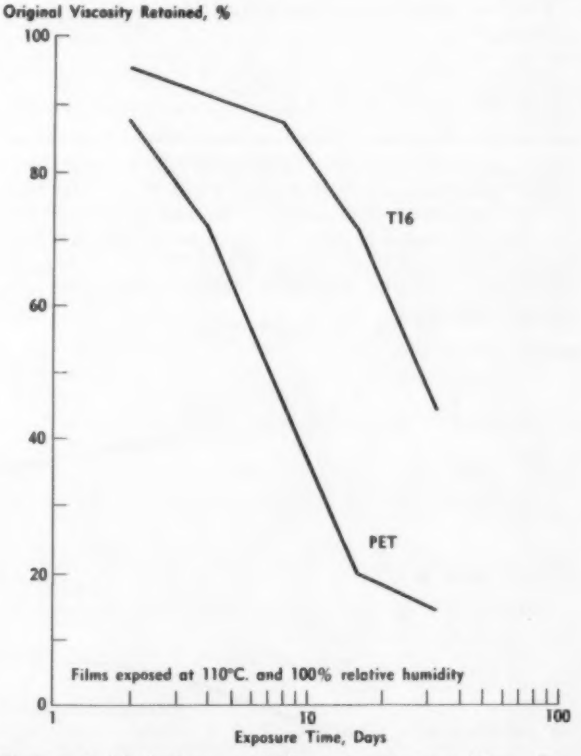


Figure 4. Hydrolytic stability of polyester films. Retention of solution viscosity (a measure of molecular weight) is much better for T16 film than for PET.

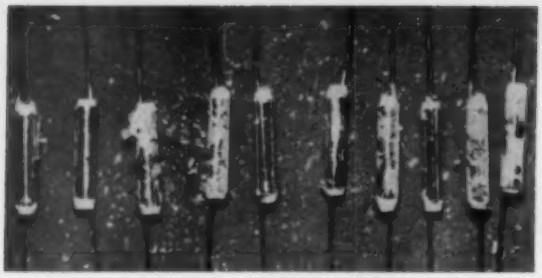


Figure 5. PET capacitors after being heated for 8 days at 110°C. and 100% relative humidity. The PET film has begun to flake off, ruining the capacitors electrically as well as physically.

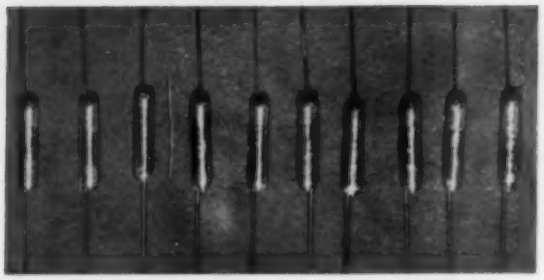


Figure 6. T16 capacitors are unaffected and their electrical properties are virtually unchanged after being heated for 8 days at 110°C. and 100% relative humidity.

Table 3. Stability of Polyesters

Property	T16	PET
Thermal stability		
Loss of inherent viscosity[a] after 35 min. at 310°C. under nitrogen, %	11	12
Oxidative stability		
Loss of inherent viscosity after 16 hr. at 200°C. in air, %	85	17
Weathering stability (3-mil films exposed outdoors in Kingsport, Tenn.)		
Retention of initial elong. after 3 mo., %	6	1
Time required to produce embrittlement, mo.[b]	9	6

[a] Inherent viscosity = $\ln \eta_{rel}/c$, determined at a concentration of 0.25 g./deciliter in 60:40 phenol:tetrachloroethane.
[b] Brittleness judged by failure of specimen when bent double, exposed side out.

These capacitors were then subjected to 110°C. and 100% relative humidity for 8 days. *Figures 5 and 6* show the PET and T16 capacitors, respectively, at the end of the test. The PET film had begun to flake off, thus ruining the capacitors electrically as well as physically. The T16 capacitors, however, were unaffected and their electrical properties were virtually unchanged.

T16 has excellent chemical resistance. It is unaffected by long immersion in aromatic and aliphatic hydrocarbons, turpentine, gasoline, organic esters, mineral acids, and alkalies. With respect to resistance to strong alkalies, in particular, it is superior to PET. PET film after 3 weeks' immersion in 10% sodium hydroxide solution lost over 50% of its original tensile strength, whereas T16 film after 4 weeks' immersion still retained more than 85% of its original tensile strength. Superior resistance to strong alkalies is a useful property for application as metallic yarn.

Water-Vapor Permeability—Water-vapor permeability was determined in accordance with ASTM E96-53T Procedure E for 1-mil T16 and PET films. The average value for T16 film was 1.8 g./100 sq. in./day; the corresponding value for PET was 2.0. T16 is relatively impermeable to water vapor and in this respect is slightly better than PET. Neither film is as good as polyethylene, however; the value for medium-density polyethylene film of the same thickness is about half that for T16. Our value for PET is in excellent agreement with the published value. Amborski and Flierl determined water-vapor permeability of 1-mil PET film at 39.5°C. (10). Assuming that permeability is proportional to vapor-pressure difference (11), their value, when converted to the same vapor-pressure difference and units of our measurement, is 2.1.

Electrical Properties—T16 film is inherently a good dielectric film. In *Figure 7*, the dielectric constant and dissipation factor at 25°C. are plotted as functions of frequency. In *Figure 8*, the dielectric constant and dissipation factor at 1 kc. are plotted against temperature, along with the same curves for commercial, electrical-grade PET. These measurements were made in accordance with ASTM D150-54T (12). The flatness of the T16 curves assures capacitance and impedance stability. *Figure 8* indicates superiority of T16 over PET for electrical purposes by reason of the improved stability with temperature of both dielectric constant and dissipation factor of T16. This effect is not surprising, in view of the difference in second-order transition temperatures (T_s) of the two polyesters: T_s determ-

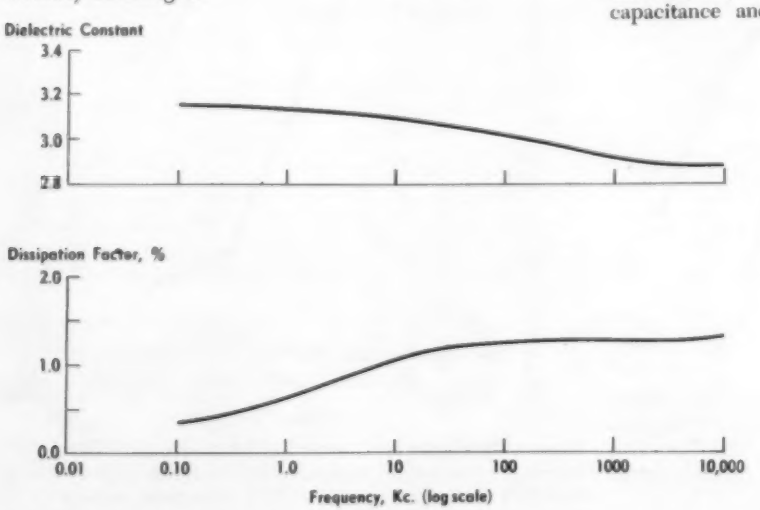


Figure 7. Dielectric constant and dissipation factor of T16 film as a function of frequency at room temperature. Relatively flat nature of these curves assures capacitance and impedance stability.

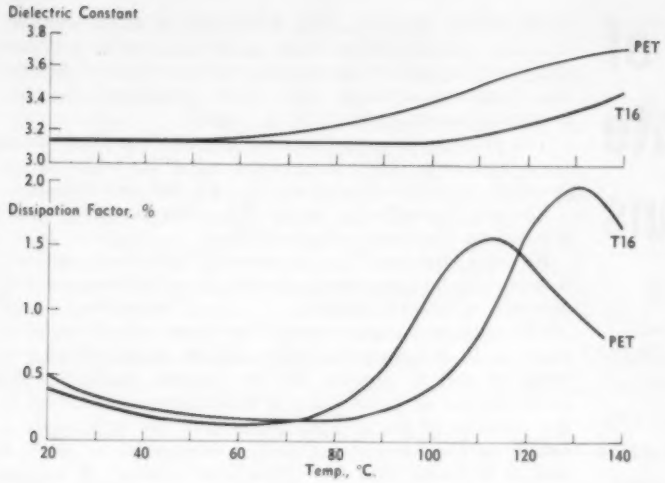


Figure 8. Dielectric properties of polyester films. T16 has better constancy of dielectric constant and dissipation factor with temperature than does PET. The peak in the dissipation factor curve occurs at about 120°C. higher temperature for T16.

mined by differential thermal analysis is some 12°C. higher for T16 than for PET. T_g for PET determined dilatometrically is of the order of 80°C. (13). The maximum in the dissipation factor-temperature curve is presumably associated with increased segmental motion in the amorphous regions occurring above T_g (14).

T16 has excellent dielectric strength, as high as 8700 v./mil on 0.5-mil film (tested at 60 cycles and 500 v./sec.). In connection with elevated-temperature dielectric strength, *Figure* 9 shows the time required for 100% failure of ten 0.05-μf. capacitors made from single layer 0.25-mil film and tested at 2,000 volts d.c. per mil for both T16 and PET films.

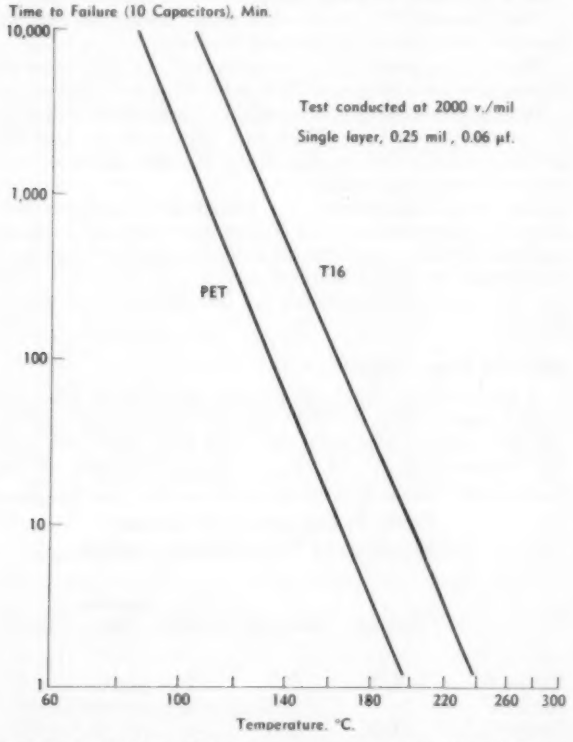


Figure 9. Effect of temperature on capacitor failure time for polyester films. Data are plotted as 1/°K., but points on abscissa are labeled as °C. At all temperatures, lifetime of the T16 capacitors is greater than that of the PET capacitors by a factor of nearly ten.

At all temperatures, lifetime of the T16 capacitors is nearly an order of magnitude longer than the PET capacitors.

In view of these data on electrical properties, it is concluded that T16 film is satisfactory for applications as AIEE Class B insulation.

Summary

Poly (1,4-cyclohexylenedimethylene terephthalate) can be processed into strong, tough, clear films having high heat-distortion temperature, low moisture susceptibility, excellent hydrolytic and chemical resistance, and superior electrical properties.

On the basis of the data presented, an over-all qualitative comparison between this polyester and poly (ethylene terephthalate) can be made, approximately as follows. For applications where strength and toughness are the sole critical properties, PET has the advantage, except that T16 has a lower density and better color. In applications where stability in severe environments, including exposure to chemicals, is the critical property, T16 has the over-all advantage, if those formulations containing antioxidants are included. For electrical purposes, the advantage lies wholly with T16, which is superior to PET in every respect.

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Acknowledgment

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A Study of Maleate and Fumarate Polyester Resins

Appreciable amounts of maleates in a polyester resin retard cure rates and affect physical properties

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The differences between isomers of α,β-unsaturated esters have been recognized for some time. Price (1) studied the reactivity of maleates and fumarates and proposed that maleates copolymerize much slower than fumarates because of steric hindrance present in the maleate. The maleate ester is not co-planar and, therefore, hinders the approach of a free radical, whereas maleic anhydride and fumarate esters are co-planar and no hindrance exists.

Lewis and Mayo (2) compared the reactivity of dialkyl maleates and fumarates with several monomers and found that the *trans* form of the ester is 6 to 20 times as reactive as the *cis* form toward styrene, vinyl chloride, and vinyl acetate radicals.

Another paper (3) dealt with the preparation and analysis of all *cis* and all *trans* polymers prepared from the appropriate forms of 2-butene-1,4-diols and ethene-1,2-carboxylic acids. These polymers were studied by saponification, X-ray, and infrared methods.

It is the purpose of this article to present a practical method of studying the effect of varying maleate and fumarate concentration ratios on the behavior of conventional type polyester resins. This effect is evident in the rates of copolymerization and in the physical properties. It is hoped that this article will lead to a better understanding of these effects.

Cast Physical Properties

Resins containing an appreciable amount of maleate have been prepared and compared to resins based on fumaric acid. The infrared curves indicate resins A and E (*Table 1*) have a high maleate/fumarate ratio (9/1). Resin C has a 1/1 ratio of maleate to fumarate. These three polyesters were prepared with maleic anhydride and processed at low temperatures to encourage formation of maleate rather than fumarate esters. Three resins with identical formulations were prepared with a molar substitution of fumaric acid for maleic anhydride (resins B, D and F). The pairs of resins have similar acid numbers and equal styrene contents. They differ only in alkyd viscosity. Maleates normally form lower molecular weight polymers and, therefore, could be expected to have lower viscosities than fumarate polyesters (8). *Table 1* indicates the composition of resins A, B, C, D, E, and F.

The physical properties of cast specimens of these resins are compared in *Table 2*. A summary of the effect of appreciable quantities of maleate on each property follows:

Flexural Strength—No major difference in this property is noted on the three resin systems.

Flexural Modulus—This property on resin A is only 67% that of resin B. Comparison of resins E and F shows a 20% decrease in flexural modulus in resin E which has a high (9/1) maleate-fumarate ratio. This same ratio is noted in resin A. It is believed a lower degree of crosslinking in resins A and E account for the greater flexibility. The lower degree of crosslinking is theorized to be caused by the presence of the maleate which does not polymerize as readily as the fumarate. A further comparison of resins C and D indicates that the appreciable amount of maleate in resin C would explain the 10% reduction in flexural modulus.

Barcol Hardness—Resins A, C, and E are softer than their straight fumarate counterparts.

Tensile Strength—Resin F is extremely brittle; resin E is definitely less brittle. Resins A, B, C and D contain other dibasic acids to reduce brittleness. Consequently, the effect of the maleate-fumarate ratio does not show as clearly as in resins E and F.

Tensile Modulus—Resins A, C and E give a lower value (as in the case of flexural modulus).

Elongation in Tension—Resins A, C and E have greater elongation, as would be expected from the above physical tests. Differences between resins E and F are extreme.

Izod Impact—No major difference here. The authors question the accuracy of the test however.

Water Absorption—The fumarates in 2 out of 3 cases are higher in water absorption. This is of debatable significance.

Heat Distortion—This definitely indicates greater rigidity in non-maleate systems. These test differences (in heat distortion) initially led to the study of other differences in maleate containing resins.

The above differences are important and have been noted in other resins as well. The resins which are basically maleates behave somewhat as if a saturated acid had been substituted for the unsaturated component; the cured resins are less rigid and apparently not crosslinked to as great a degree.

Gel and Cure Properties

A study was made of the SPI Gel test data on blends of resin A and resin B. As the fumarate content increased the gel time, propagation time and total time decreased while the exotherm increased. These changes indicate definite

Table 1. Experimental Resins Composition of Polyesters (in moles)

	Maleate[1]	Fumarate	Phthalate	Isophthalate	Glycol[2]
Resin A	4.5	0.5	5	—	10
Resin B	—	5.0	5	—	10
Resin C	3.0	3.0	—	4	10
Resin D	—	6.0	—	4	10
Resin E	9.0	1.0	—	—	10
Resin F	—	10.0	—	—	10

[1] Ratio of maleate to fumarate determined by infrared technique.
[2] Resins A, B, E, and F contain propylene glycol; resins C and D contain 8 moles diethylene glycol, 2 moles ethylene glycol.

increases in the reactivity of the resin as the maleate/fumarate ratio decreases (*Table 3*).

The SPI Gel test data on resin E and resin F also indicate the same trend. The four resins (and blends) were tested for minimum cure. Cure times definitely increased as the maleate/fumarate ratios increased (*Table 4*).

The data in *Table 5* stresses another effect of maleate groups. These resins have only 15 mole percent unsaturated acid. Both resins contain cobalt and an amine to permit room temperature gelation and cure. The difference in MEK peroxide gel and cure rates with the two resins is significant. The benzoyl peroxide gelation times are similar for both the maleate and the fumarate, but the fumarate attains a faster cure.

Table 2. Cast Physical Properties[1]

Properties	A.S.T.M. Test Method[2]	Resin A	Resin B
Flexural Strength, psi.	D-790-49T	15,000	13,000
Flexural Modulus, x 10^6 psi.	D-790-49T	0.39	0.60
Barcol Hardness[3]		45-50	58-62
Tensile Strength, psi.	D-638-52T	7,500	7,500
Tensile Modulus, x 10^6 psi.	D-638-52T	0.44	0.55
Elongation, %	D-638-52T	2.3	1.4
Compression, psi.		20,000	25,000
Izod Impact, Notched, ft.lb./in.		0.15	0.24
Water Absorption, %	D-570-54T	0.18	0.16
Heat Distortion, 264 psi., °C	D-648-56	41	70

[1] Resin catalyzed with 1% BPO, gelled in ⅛ inch glass cell at 140°F; cured for 1 hour at 170°F and 1 hour at 250°F. (Same conditions used in all following castings).
[2] Standard ASTM tests are used as indicated in all succeeding tabular data.
[3] Measured with Barcol Instrument #934-1 (Barber Coleman Company). (Resin A has a 9/1 maleate/fumarate ratio); resin B contains no maleate.)

Properties	Resin C	Resin D
Flexural Strength, psi.	18,000	19,000
Flexural Modulus, x 10^6 psi.	0.46	0.50
Barcol Hardness	36-42	45-51
Tensile Strength, psi.	10,000	11,000
Tensile Modulus, x 10^6 psi.	0.42	0.45
Elongation, %	3.5	3.3
Izod Impact, Notched, ft.lb./in.	0.24	0.22
Water Absorption, %	0.15	0.25
Heat Distortion	47°C	68°C

(Resin C contains a 1/1 ratio of maleate to fumarate; resin D contains no maleate.)

Properties	Resin E	Resin F
Flexural Strength, psi.	15,000	14,000
Flexural Modulus, x 10^6 psi.	0.42	0.52
Barcol	49-55	55-60
Tensile Strength, psi.	9,000	3,000
Tensile Modulus, 10^6 psi.	0.40	0.47
Elongation, %	3.9	0.6
Compression, psi.	18,000	21,000
Izod Impact, Notched, ft.lb./in.	0.23	0.27
Water Absorption, %	0.22	0.45
Heat Distortion, 264 psi., °C	48	118

(Resin E contains a 9/1 ratio of maleate to fumarate; resin F contains no maleate.)

Table 3. SPI Gel Data

% Resin A	% Resin B	SPI Gel	Propagation	Total Time	Peak Temperature
0	100	3.6	2.0	5.6	411
5	95	4.1	2.1	6.2	406
10	90	4.4	1.9	6.3	406
20	80	3.9	2.3	6.2	396
40	60	4.0	2.7	6.7	369
60	40	4.4	3.3	7.7	335
80	20	5.2	5.4	10.6	290
90	10	5.3	9.5	14.8	256
95	5	5.4	10.7	16.1	240
100	0	6.1	12.5	18.6	227
% Resin E	**% Resin F**				
0	100	2.2	1.1	3.3	469
25	75	1.8	1.1	2.9	461
50	50	2.2	1.3	3.5	450
75	25	2.8	1.8	4.6	435
100	0	4.6	4.4	9.0	377

[1] SPI Gel Test: This test is conducted on a sample of resin catalyzed with 1% BPO and placed in a 180°F bath. Gel time is measured as the length of time required for the resin to proceed from 150°F to 10°F above bath temperature. Propagation time is the time from 10°F above bath temperature to peak exotherm, and total time is the sum of these two. This information is automatically recorded by a Brown Potentiometer Recorder Model #153X17P-11-111-30. The test is conducted according to standard conditions set by the Society of the Plastics Industry, Inc. Reference SPI Proceedings, VI, Section 1, pp. 3-4, (1951).

Analytical Technique

One of the difficulties involved in studying the behaviors of mixtures of the ester isomers is that of determining the relative amounts of the two forms present in the polyester resins. Walton and Hughes (4) studied the infrared spectra

Table 4. Minimum Cure Data[1]

% Resin A	% Resin B	½ Minute	1 Minute	1½ Minutes	2 Minutes	5 Minutes
—	100	50-65	—	—	—	—
10	90	45-65	—	—	—	—
20	80	0-35	30-45	40-50	—	—
% Resin E	**% Resin F**					
—	100	60-70	—	—	—	—
25	75	55-65	—	—	—	—
50	50	50-60	—	—	—	—
75	25	0	0-35	30-45	40-50	—
100	—	0	—	0	0	30-40

[1] Minimum Cure Test: This test is conducted by preparing a number of 2" x 2" laminates using 10 plies of 128-38 Volan finish glass cloth and the resin catalyzed with 1% benzoyl peroxide. One laminate is then placed between two metal platens heated to 230°F. After a given length of time, the laminate is removed, cooled to room temperature and measured for hardness using the Barcol tester. This procedure is repeated on each succeeding laminate varying the time length by ½ minute intervals (longer or shorter, whichever is necessary) until an average Barcol reading of 40-50 is obtained. The minimum length of time required to reach this hardness is referred to as the minimum cure. (The numbers beneath the cure times in this chart are Barcol readings.)

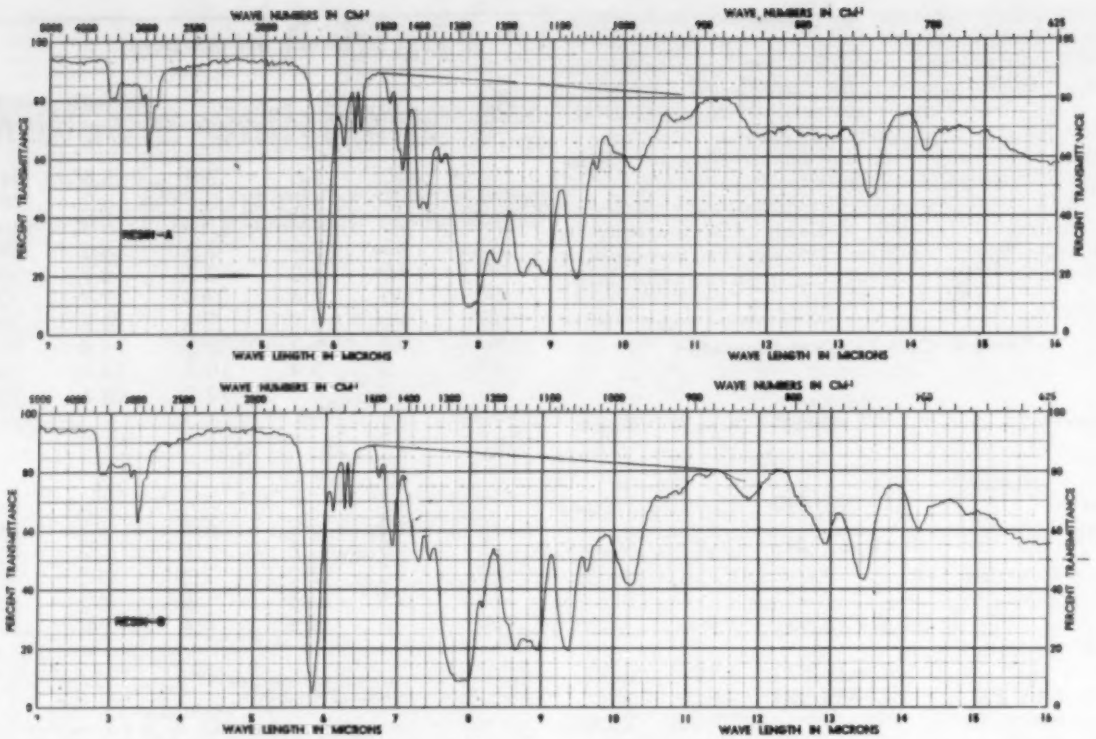


Figure 1. Infrared curves of propylene maleate-phthalate (Resin A) and propylene fumarate-phthalate (Resin B)

of a number of maleates and fumarates. From this study they devised an analytical method based on the broadening of a weak 8.17μ infrared band of fumarates with increasing amounts of maleates (5). This method is insensitive to large amounts of maleates (about 50%) and has been found to offer poor reliability. The infrared method described by Bobalek and Chiang (6) appears to be questionable. Study of the comparisons of infrared curves of maleates and fumarates will show differences not previously discussed for use in analytical procedures. Of most interest is the appearance in maleate polyesters of a sharp, moderately strong absorption band at 7.17μ not present in fumarates. This band is probably due to an ethylenic CH in-plane deformation in the *cis* configuration (7). While it is always advisable to examine the whole curve for interpretation, the intensity of this 7.17μ band has been found to give an excellent measure of the relative amounts of the maleate/fumarate forms. Interferences in commercially important polyesters result only when chlorinated aromatic constituents are present. As a further check on relative concentrations, the increase in absorption at 8.42μ will give a measure of the maleate form.

A measured amount of the resin (2 drops) was spread on a rock salt plate and baked under an infrared lamp for ten minutes to remove the monomer. The maximum temperature reached was 190°F. There was no difference in the spectrum of the film thus prepared from the spectrum of the film made by first stripping off the monomer, dissolving the polyester in a volatile solvent such as acetone or methylethylketone, and drying under vacuum for four hours at room temperature. When the same amount of resin is placed on the plate, films of nearly the same thickness are attained. The spectra were recorded relative to air with a Baird Model 4-55 Double Beam Recording Infrared

Table 5. Room Temperature Gel and Cure Data (measured in minutes)

	Resin G	Resin H
1% BPO, Gel Time[1]	15-22	15-27
1% DDM, Gel Time	4.1-6.0	2.0-2.7
1% DDM 100/15, Gel Time[2]	11-20	4.5-5.8
1% DDM 100/15 mix[2]		
Gel Time	11-20	4.5-5.8
Propagation Time	14-23	9-13
Total Time	25-43	15-19

[1] Gel Time: Time from catalyzation to first sign of gelation in 6 ounce custard cup at 77°F. Propagation time is the period from gel to peak exotherm, and total time is the sum of these two. Exotherm is measured with a thermocouple.
[2] This test was made on the resin with 15 parts additional styrene.
Resin G—Resin containing approximately 15 mole percent maleate.
Resin H—Resin containing approximately 15 mole percent fumarate.

Table 6. Measurement of Ratio of Maleate to Fumarate in Polyester Systems by Infrared Absorption

% Resin A	% Resin B	Ratio Maleate/ Fumarate	Calculated Ratio A7.17 / A7.45	Calculated Ratio A8.42 / 7.52
70	30	7/3	78/22	80/20
50	50	1/1	53/47	46/54
3	97	3/97	0/100	0.5/99.5
% Resin E	**% Resin F**			
5	95	5/95	2.5/97.5	3/97
70	30	7/3	79/21	80/20
50	50	1/1	48/52	63/37

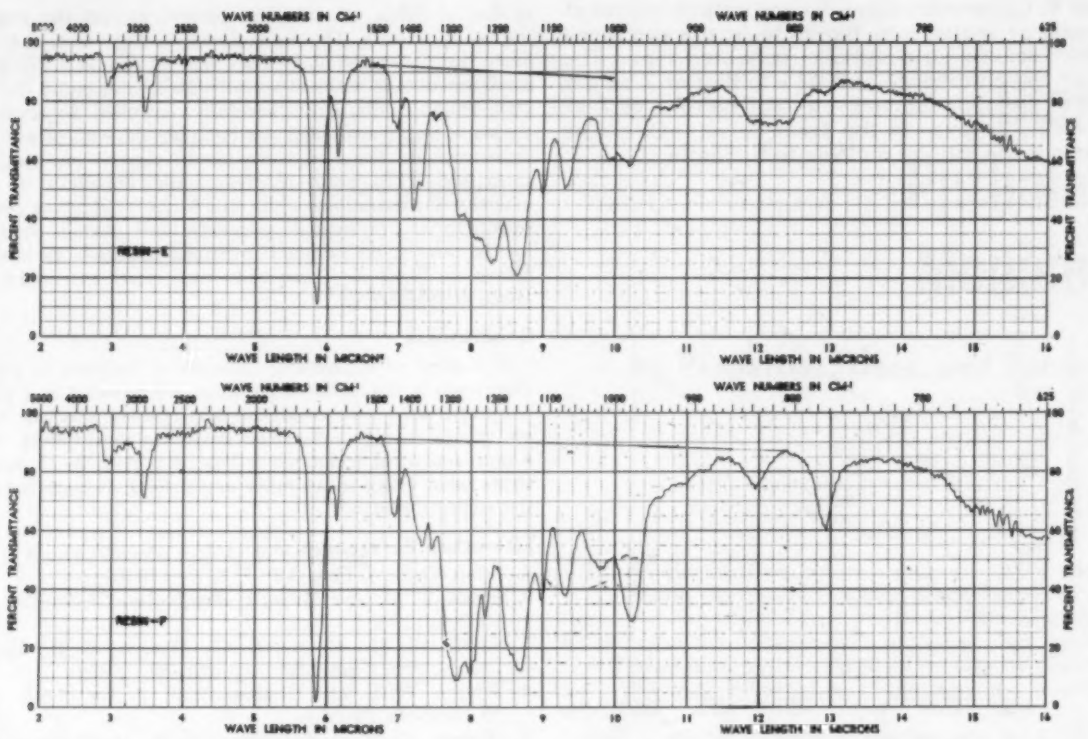


Figure 2. Infrared curves of propylene maleate (Resin E) and propylene fumarate (Resin F)

Spectrophotometer. Curves for resin A and resin B are shown in *Figure 1*. Curves for resin E and resin F, and diethyl maleate and diethyl fumarate (Eastman Organic Chemicals, Nos. 1430 and 1431) are also shown (*Figures 2 and 3* respectively). Resins B and F contain no visible amount of maleate. Resins A and E contain no visible amount of fumarate.

Since the film thickness cannot be controlled accurately by this method, a ratio technique was devised to eliminate the errors from film thickness variations. A solvent suitable for polyesters which is transparent in the required regions is unknown.

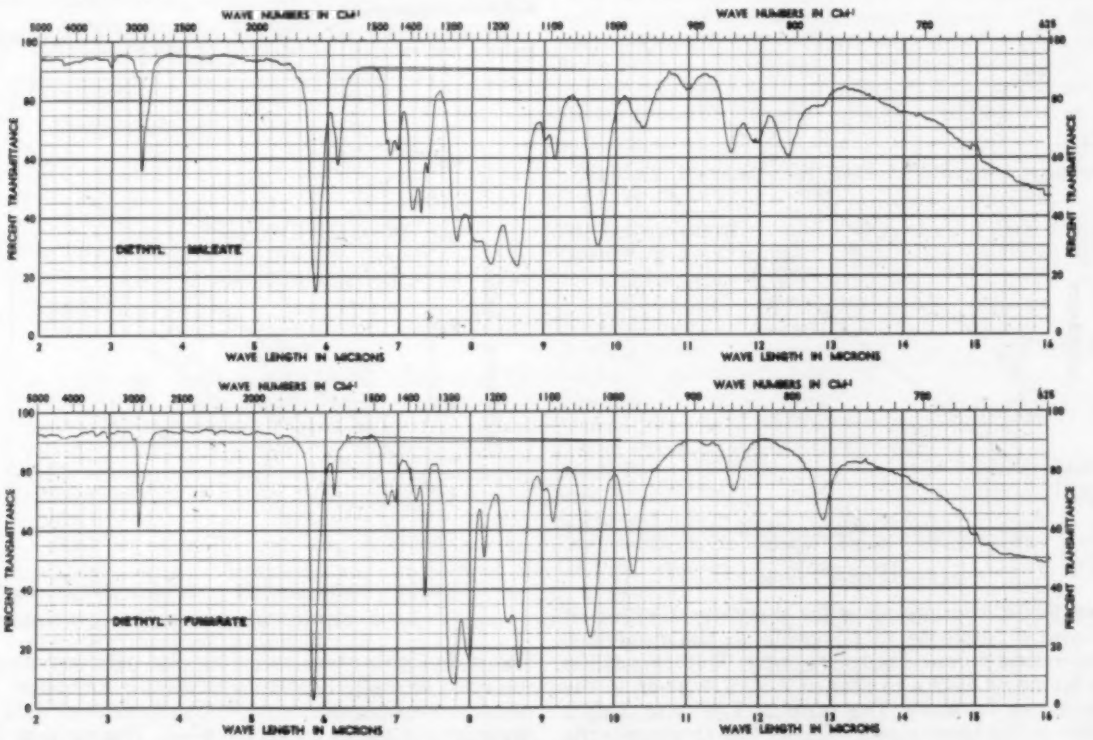
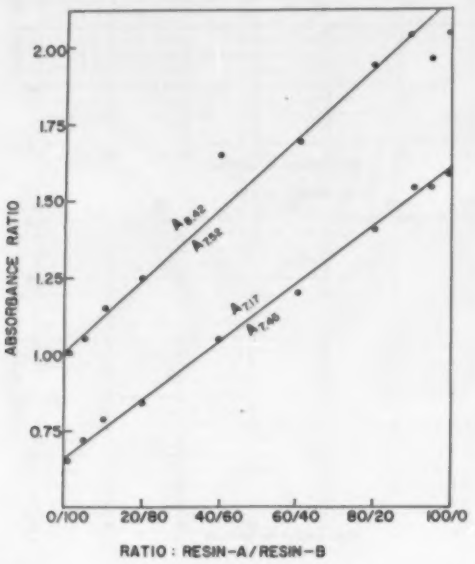


Figure 3. Infrared curves of diethyl maleate and diethyl fumarate

Figure 4. Calibration curve for the determination of the ratio of maleate to fumarate in the propylene glycol-maleic-fumaric-phthalic polyester type. The ratio of the absorbance at 8.42 μ to that at 7.52 μ is given in the upper curve (—●—). The ratio at 7.17 μ to 7.45 μ is given in the lower curve —O—. The abscissa is the ratio of maleate to fumarate.



Calibration curves were prepared from mixtures of the three pairs of isomers shown in *Figures 1, 2 and 3*. The transmittance was measured at 7.17μ, 7.45μ, 7.52μ, and 8.42μ and a base line correction applied to the corresponding absorbance (—log T). The ratio of the absorbance at 7.17μ to that at 7.45μ was plotted against the concentration of maleate, and the ratio of the absorbance at 8.42μ to that at 7.52μ was likewise plotted against the concentration of maleate. These are shown in *Figures 4, 5 and 6*. Since the absorption curve rises very steeply at 7.17μ when small amounts of maleate are present, it is essential that the wave length calibration be carefully controlled. Expansion of the wave length scale will also facilitate the ease of accurate measurement. The two wave length regions are used because the 7.17μ band affords greatest sensitivity at high maleate concentrations while the 8.42μ band gives greater sensitivity at low maleate concentrations. Results achieved by the analyst on prepared mixtures unknown to him are shown in *Table 6*. These tests were used to confirm the above conclusion.

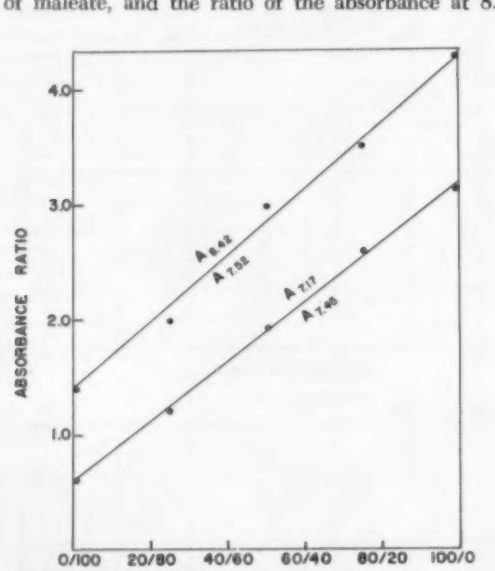


Figure 5. Calibration curve for the determination of the ratio of maleate to fumarate in the propylene glycol-maleic-fumaric polyester type. The ratio of the absorbance at 8.42 μ to that at 7.52 μ is given in the upper curve (—●—). The ratio at 7.17 μ to 7.45 μ is given in the lower curve —O—. The abscissa is the ratio of maleate to fumarate.

Conclusions

The effect of appreciable amounts of maleates in a polyester resin is significant. Cure rates are retarded and physical properties of the resins are also notably affected; maleate groups tend to soften and flexibilize the product. With a new analytical technique it has been possible to demonstrate what effect measurable amounts of maleate have on the resin properties.

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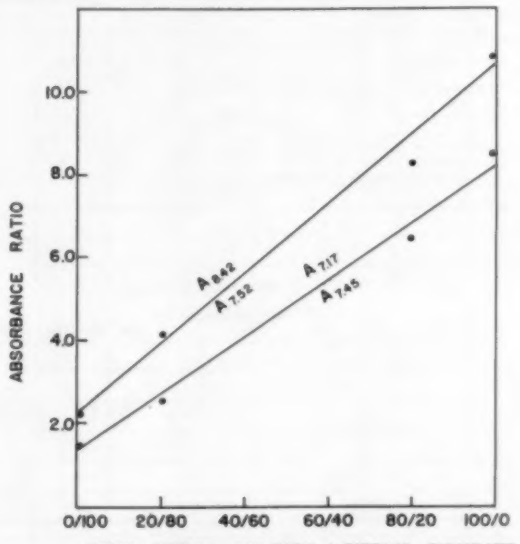


Figure 6. Calibration curve for the determination of the ratio of diethyl maleate to diethyl fumarate. The ratio of the absorbance at 8.42 μ to that at 7.52 μ is given in the upper curve (—●—). The ratio at 7.17 μ to 7.45 μ is given in the lower curve —O—.

Properties, reactions, commercial applications and potential new uses of DAP. A "case book" of pertinent patent references prepared specially for the SPE Journal

Diallyl Phthalate Monomer

Its Properties, Uses, and Potential

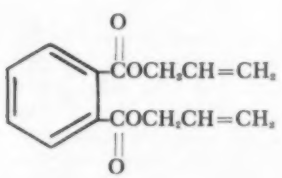
Gene Nowlin and L. S. Burnett

FMC Corporation

Diallyl phthalate (DAP) is a unique monomer which has received an increasing amount of attention by polymer scientists and plastics manufacturers in the past few years. Its low volatility, long shelf-life, and efficacy in imparting heat resistance, good electrical properties, and mechanical strength to thermosetting resins are factors responsible for its growing use as a cross-linking agent in a number of resin systems.

Properties

Diallyl phthalate,



is a colorless, high boiling liquid which has the ability to react with a wide variety of unsaturated monomers and resins. Typical properties of the monomer are listed in *Table 1*. Its vapor pressure (only 2.4 mm of mercury at 150°C) is considerably lower than that of styrene (944 mm of mercury at 150°C).

This low volatility and long shelf-life are responsible for its adoption in the production of stable thermosetting compositions which have excellent handling characteristics and which can be stored for extended periods of time.

The shrinkage of DAP during polymerization is only 11.8% by volume. This is quite low compared to the shrinkage of other commercial monomers. For example, the shrinkage of styrene during polymerization is about 30% higher, viz., 17%.

Neither the monomer nor its prepolymer evolve water or other volatile by-products during polymerization or cure since these are addition-type polymerizations. This characteristic gives the prepolymer an advantage over condensation thermosetting resins in that curing may be effected at lower pressures and problems of blistering and gassing are eliminated.

DAP is soluble in methanol, acetone and most common polar organic solvents. It is insoluble or has limited solubility in water, gasoline, mineral oil, glycols, glycerol, and some amines.

Reactions and Uses

Since DAP contains two allyl (vinyl-type) groups, it can form a thermosetting homopolymer. It can also function as a cross-linking comonomer to form tightly knit thermosets with polyesters or other unsaturated polymers or by copolymerization with other vinyl monomers. The allyl groups have little or no tendency to polymerize at ordinary temperatures in the absence of initiators. Even in the presence of initiators the monomer remains unpolymerized at tem-

Table 1. Properties of Diallyl Phthalate Monomer

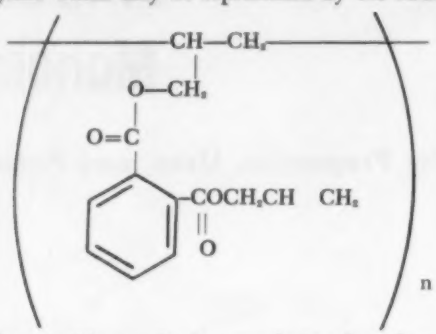
Molecular Weight	246.35
Density @ 25°C, g/ml	1.132
Refractive Index @ 25°C	1.518
Viscosity @ 25°C, centipoises	12
Boiling Point @ 760 mm, °C	300[a]
Boiling Range @ 4 mm, °C	157 to 165
Mid-Boiling Point @ 4 mm, °C	161
Freezing Point, °C	−70[b]
Vapor Pressure @ 150°C, mm Hg	2.4
Vapor Pressure @ 200°C, mm Hg	27.0
Flash Point, °F (°C)	330 (166)
Fire Point, °F (°C)	359 (182)
Surface Tension @ 25°C, dynes/cm	34.4
Specific Heat 50 to 150°C, cal/g/°C	0.50[c]
GE Gel Time, min. (1% benzoyl peroxide)	41.0
Thermal Expansion @ 10 to 40°C, in/in/°C	0.00076
Weight Per Gallon @ 25°C, lbs	9.33

[a] Extrapolated value.
[b] Viscous liquid.
[c] Average value.

peratures of 75-100°F for unusually long periods of time. This is one of its distinct advantages as a cross-linker in polyester formulations.

Prepolymers

When DAP is homopolymerized under carefully controlled conditions, it yields a free-flowing, white, powdery prepolymer which may be represented by the structure:



This thermosetting resin is manufactured and marketed by FMC under the tradename DAPON.

Most of the shrinkage, which accompanies vinyl polymerizations, occurs during the formation of the prepolymer. Consequently, when the prepolymer is cured during molding, the shrinkage is less than 1% by volume. Another important attribute of this prepolymer is that it cures very rapidly because very little additional polymerization is needed to convert it into a compact cross-linked thermoset.

Typical properties of completely polymerized DAP monomer (or cured DAPON) are listed in *Table 2*. Particularly outstanding among these properties are the resistance to thermal stress (note 155°C deflection temperature), electrical properties and hardness. The cured resin is further characterized by excellent dimensional stability, retention of good electrical properties on exposure to high temperature and high humidity, and outstanding chemical resistance.

The DAP prepolymer is used chiefly in molding compounds (particularly for electronic and electrical parts, decorative laminates, and industrial laminates.

The ability of DAP to cross-link plus its ease of handling are responsible for its use to make a number of end-products with good mechanical, chemical, thermal and electrical properties. The principal commercial uses of this tetrafunctional monomer, include the following:

1. Prepolymer molding and laminating compounds
2. Cross-linking agent for polyesters
3. Carrier for adding catalysts and pigments to polyesters
4. Modifier in vinyl plastisols
5. Impregnating and bonding agent
6. Plasticizer

Other applications for which DAP is recommended include:

1. Cross-linker in polyurethane foams
2. In epoxy formulations
3. In rubber compounds
4. As a comonomer to upgrade the quality of other monomers and polymers

Cross-Linking Agent for Polyesters

One of the major commercial applications of DAP monomer is as a cross-linking agent for unsaturated polyester resins. Numerous commercial applications are reported (1) for these diallyl phthalate-polyester blends. Most unsaturated polyesters containing monomer are not very stable during storage, particularly at high temperatures and in the presence of air. Their tendency to gel or cross-link is much greater when the cross-linking monomer is styrene instead of diallyl phthalate. The favorable curing and handling characteristics of DAP monomer are advantages which are exploited to produce finished parts of consistent quality (2). It is frequently used in preference to styrene in polyesters in such applications as preimpregnated fabrics, premix molding compounds and catalyst carriers in which its

Table 2. Typical Properties of Pieces Molded From DAP Prepolymer

Rockwell Hardness (M Scale) ASTM D785-51	114-116
Barcol Hardness	42-43
Density @ 25°C gm/ml	1.270
Izod Impact (ASTM D256-56), ft.lbs./in. notch	0.3
Deflection Temperature, 10 mils deflection	
(ASTM D648-56) (Formerly known as heat distortion) @ 264 psi, °C	155
@ 66 psi, °C	160
Compressive Strength (ASTM D695-54), psi	22,000-24,000
Flexural Strength (ASTM D790-59T), psi	7,000-9,000
Refractive Index @ 25°C (ASTM D542-50)	1.571
Water Absorption, 24 hrs. @ 25°C (ASTM D570-59aT), %	0.0-0.2
Tangent Modulus of Elasticity in Bending (ASTM D790-59T), psi	0.05×10^6
Dielectric Constant (ASTM D150-54T) 60 cycles	3.5
10^3 cycles	3.6
10^6 (megacycles)	3.4
Volume Resistivity @ 25°C (ASTM D257-58)	1.8×10^{16}
Surface Resistivity @ 25°C (ASTM D257-58) ohm	9.7×10^{15}
Dielectric Strength @ 25°C, step-by-step, volts/mil (ASTM D149-59)	450
Arc Resistance (ASTM D495-58T) seconds	118
Dissipation Factor @ 25°C (ASTM D150-54T)	
60 cycles	0.010
10 cycles	0.009
10^6 (megacycles)	0.011
Gardner Color (unit)	7

very low volatility, high flash point, good storage stability and viscosity offer processing and end-property advantages.

The DAP-polyester blends are also used in industrial laminates prepared by the wet-layup method, impregnation of metal castings, banding tapes and mat or preform binders. DAP monomer is used as a reactive vehicle or solvent to introduce catalysts or pigments into polyester resin compositions.

The amount of DAP used in polyesters varies from about 20-50 weight per cent. Since DAP copolymerizes quite rapidly with maleate or fumarate double bonds, highly unsaturated polyesters may be used when fast cure rates are required.

Industrial Laminates: The non-volatility of the DAP-polyester blends makes them ideal for fabricating large glass-reinforced parts, e.g., radomes, by the hand-layup method since there is essentially no loss of monomer during cure. The relatively low exotherm (compared to styrene-polyester systems) of these DAP-containing resins manifests itself in strain-free and bubble-free cured parts. The DAP-polyester glass cloth laminates qualify under Military Specifications Mil-R-7575B, Types I and II.

Premixes: DAP, in concentrations of 20-40 weight per cent, has a beneficial effect when used in polyester premixes. The high viscosity of this monomer (as compared to that of styrene) means better tack than that of the styrene-polyester premixes. Wet-out of fiber and filler is improved and resin squeeze-out is minimized.

Cured premix parts have good chemical resistance in addition to good mechanical and electrical properties. They also have high flexural strength, good impact resistance and good hot strength. Surface finishes are excellent and they exhibit excellent outdoor weatherability. The use of DAP in place of styrene eliminates gassing and blistering during molding since vaporization of monomer is negligible.

Impregnation of Metal Castings: DAP and DAP-polyester blends are used to impregnate metal castings of all types. This is frequently necessary to first seal the pores when the castings are to be used in applications involving pressure or vacuum, prevent bubble formation in protective coatings resulting from gases trapped in the pores, and finally prevent contamination of the pores and subsequent internal corrosion by metal bath salts.

Banding Tapes: Banding tapes impregnated with DAP-polyester resins are used to wrap motor armatures (3). These uncured preimpregnated tapes have the desired amount of parallel strand bonding and little or no interlaminar tack so that blocking poses no problem.

Catalyst and Pigment Carrier: DAP is finding favor with boatbuilders who employ it as a vehicle or carrier for addition of catalyst and pigments to polyester resins. It is more suitable than other carriers (inert, volatile solvents) because of its aforementioned properties and because it is not polymerized by the catalyst at ambient temperatures. Since the DAP carrier becomes an integral part of the cured resin through copolymerization, it does not cause the problems of solvent removal or dilution encountered when the common inert carriers are employed. From 2-10 weight per cent of DAP monomer containing catalyst can be added to styrene-containing polyesters without significantly increasing the gel times or cure times. Ultimate mechanical properties are thereby maintained or, in many instances, improved.

Copolymerization of Diallyl Phthalate

The double bonds of DAP have a tendency to copolymerize rapidly with a number of other monomers and unsaturated polymers. By proper selection of comonomers the copolymerization of diallyl phthalate can be made to proceed many times faster than the homo-polymerization.

Diallyl phthalate has particularly strong copolymerization tendencies with monomers that have electron withdrawing groups attached directly to the carbon-carbon double bond. These comonomers include maleic anhydride (4), maleates and fumarates (5) (monomers and polyesters), acrylates (6), methacrylates (7), acrylonitrile (8) and acrylamide. Diallyl phthalate also copolymerizes with monomers such as styrene (6, 9) and others (10) whose carbon-carbon double bonds have a relatively high electron density.

Advantage can be taken of the copolymerizability of diallyl phthalate to improve properties of vinyl polymers. For example, the intrinsic good properties of cured DAP, such as resistance to thermal stress, resistance to solvents, high rigidity, etc. (shown in *Table 2*) can be imparted to styrene copolymers (9).

Other Uses for Diallyl Phthalate

Diallyl phthalate can be used in thixotropic coatings designed for applications where drainage is objectionable (11). The formula consists of approximately equal parts of diallyl phthalate, diethylene glycol maleate and clay. The clay maintains the composition in a firm state even at 100°C, while mechanical agitation converts it to a fluid. A suggested application of these coatings is on high voltage equipment where unequal thermal conductivity, which would arise if the coating thickness was uneven, would lead to corona discharge.

DAP and the DAP prepolymer are used in a bonding resin for abrasive grinding wheels which require resilience, high bonding strength and good heat resistance in special applications where phenolic resins are inadequate.

A copolymer of diallyl phthalate with allyl laurate has been claimed as a viscosity index improver for lube oils (12). Copolymers of DAP with a number of other monoallyl esters have been reported (13). These copolymers are also suggested as pour point improvers, corrosion reducers and color stabilizers.

Diallyl phthalate has been copolymerized with vinylidene chloride to prepare moldable products that have very good solvent resistance (14).

Dyes for cellulose acetate fabric are protected from fading by addition of diallyl phthalate monomer.

By incorporating DAP into vinyl chloride-vinyl acetate copolymers, their stability against deterioration by light is improved (15).

When DAP is used as a cross-linking agent during the polymerization of methyl methacrylate, it produces a resin which has better surface hardness and better elasticity than the unmodified polymethyl methacrylate (7). DAP-acrylonitrile copolymers have higher resistance to organic solvents than do acrylonitrile homo-polymers (8). The use of diallyl phthalate copolymers in combination with melamine or urea-formaldehyde results in thermosetting compositions that have improved adhesion to glass fibers (16).

Diallyl phthalate has been used to form rigid polyurethane foams with diisocyanates and castor oil (17). These compositions are outstanding in energy absorption, dimensional stability, low moisture absorption and compressive strength compared to conventional polyurethanes of equivalent density. Such foams can be made continuously in commercial machines or foamed-in-place by spray devices.

Summary

The low volatility, innate stability at ambient temperatures, low shrinkage during polymerization, and good handling characteristics of diallyl phthalate make it a versatile formulating ingredient in the plastics industry. It is effective in many cases, in imparting heat resistance, chemical and solvent resistance, good electrical properties,

and mechanical strength to thermosetting resins. It is used to advantage as a cross-linking monomer in polyesters in applications, such as preimpregnated laminates, wet lay-up laminates, and premixes, where long shelf-life, low volatility and high flash points are desirable. It is also being exhibited as a carrier for catalysts and pigments, as a bonding and impregnating agent, in banding tapes, as a modifier in plastisols, and as a cross-linking agent in the preparation of rigid polyurethane foams.

This monomer is the forerunner of DAPON, a prepolymer, which finds application in molding compounds, decorative laminates and industrial laminates because in the cured state, it has excellent dimensional stability, outstanding electrical properties, even after exposure to high humidity and high temperature, good resistance to thermal stress and good chemical resistance.

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PLASTIC FLOW IN INJECTION MOLDS

How plastic flow is influenced by—
- *resin temperature*
- *mold temperature*
- *injection pressure*
- *gate design*

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Difficulties encountered from time to time in molding parts from various plastic materials frequently raise questions concerning plastic flow in injection molds and the effect of gating, molding conditions, and material selection on plastic flow patterns. Most frequently such questions are answered on the basis of theoretical suppositions or remain unanswered due to non-availability of special equipment required for experimental investigation and the relatively high cost of conducting such studies.

Recent laboratory work conducted in connection with the development of linear polyethylene materials disclosed a convenient and economical method for tracing plastic flow in injection molds. This method employed a transfer tracer technique which consisted of placing marks on the surfaces of the core and cavity sections of the mold at predetermined locations using various marking mediums. Subsequent injection of the plastic in the mold caused the molten plastic to pick up particles of the marker which were then carried along in the melt stream. The flow of the plastic in the mold thereby became readily visible as traced in the surfaces of the molded parts.

Transfer tracer techniques may be used to determine the effect of processing variables on plastic flow in injection molds thereby permitting control of turbulence and molded-in stresses. The effect of several processing variables on plastic flow such as material temperature, mold temperature, injection pressure and gate design are described in this article. Plastic flow patterns derived from the transfer tracer technique utilizing direct gating and edge gating in combination with several molds are illustrated.

Transfer Tracer Mediums

Seven possible transfer tracer mediums were evaluated for effectiveness with high density polyethylene (melt index 5.0), cellulose acetate (medium hard and medium soft flows) and general purpose polystyrene molding materials. Each of these marking mediums shown in *Table 1* were applied to the core and cavity sections of a conventional tensile bar injection mold and were evaluated for transfer and registration characteristics when molded with these three molding materials.

Only two of the seven marking mediums evaluated with these molding materials showed the characteristics desired for use as transfer tracer mediums. These were the red crayon (wax pencil) and the solution of red pigment (cadmium red) and acetone. Both of these mediums showed good transfer and registration characteristics when molded with high density polyethylene but were unsatisfactory for use with cellulose acetate and polystyrene. In general, the red crayon was considered superior to the solution of pigment and acetone for use as a transfer tracer medium because of slightly better transferability. Results from this evaluation are shown in *Table 1*.

Therefore the scope of this investigation was confined only to the work performed with high density polyethylene utilizing the most suitable transfer tracer medium, red crayon.

Transfer Tracer Techniques Applied

This study was performed using a single sprue gated flat disc (5" O.D. x 0.180") mold. High density polyethylene was molded in the form of flat discs in a four-ounce Lester injection molding machine using a 45-second cycle.

LATEST TEST RESULTS

Injection molding experiments conducted with fast ram speeds showed that high density polyethylene was characterized by end-over-end flow. This type of flow was changed to plug flow by reducing ram speed and accordingly injection velocity. Since cellulose acetate and polystyrene failed to promote transfer displacement of the tracer and end-over-end flow, as in the case of high density polyethylene, with conventional molding equipment, it was felt that end-over-end flow could possibly be developed with these materials by using higher injection velocities. An additional experiment performed to test this supposition indicated that higher injection velocities developed through the use of a flat nylon shut-off nozzle and small bore cylinder failed to promote end-over-end flow with these materials.

Table1. Evaluation of Transfer Tracer Mediums

Medium	High Density Polyethylene (Melt Index 5.0)	Cellulose Acetate (MH and MS flows)	Polystyrene (General Purpose)
Chalk (red)	No transfer	No transfer	No transfer
Crayon (red)	Good transfer	No transfer	No transfer
Ink Pen (yellow)	No transfer	No transfer	No transfer
Pigment (red) (a) + acetone	Good transfer	No transfer	No transfer
Pigment (red) (a) + diethyl phthalate	No transfer	No transfer	No transfer
Pigment (red) (a) + styrene monomer	No transfer	No transfer	No transfer
Methyl orange + acetone	No transfer	No transfer	No transfer

[a] Cadmium red

Basic Flow Pattern—Both the core and cavities of the mold were marked at various locations with red crayon prior to molding at 400°F. Through a series of successive shots, the plastic flow pattern in the mold was traced by measuring at various locations the transferred red crayon marks. In most instances these marks appeared on the opposite face of the part and mold from which they were originally applied. An exception to this trend was found to exist where the mold was marked within one half inch of the sprue on the face of the sprue bushing. In this case no transfer was obtained. It was also noted that the transferred marks were displaced from their original location toward the periphery of the disc.

This end-over-end flow pattern and transfer displacement as determined by transfer tracer techniques are illustrated in *Figure 1*. This figure illustrates the transfer displacement obtained when both the cavity and sprue halves of the mold were indexed with red crayon. Marks placed on the cavity half of the mold at locations "A" and "C" were transferred and displaced respectively to locations "B" and "D" on the opposite side of the mold. Similar marks ("G" and "J") placed on the sprue half of the mold were transferred and displaced respectively to the cavity side of the mold (locations "H" and "K"). These flow paths (see arrows in diagram) demonstrated the presence of end-over-end flow.

An examination of this *Figure* also showed that no transfer was obtained when the sprue half of the mold was marked with red crayon (see F) within one half inch of the sprue. Failure of the crayon to transfer from this point may be attributed to the lack of high velocity flow in this area.

Effect of Molding Conditions on Flow—To determine the effect of processing conditions on possible rearrangement of flow patterns and transfer displacement in the flat disc mold, specimens were molded on a 45-second cycle using high density polyethylene (melt index 5.0) and

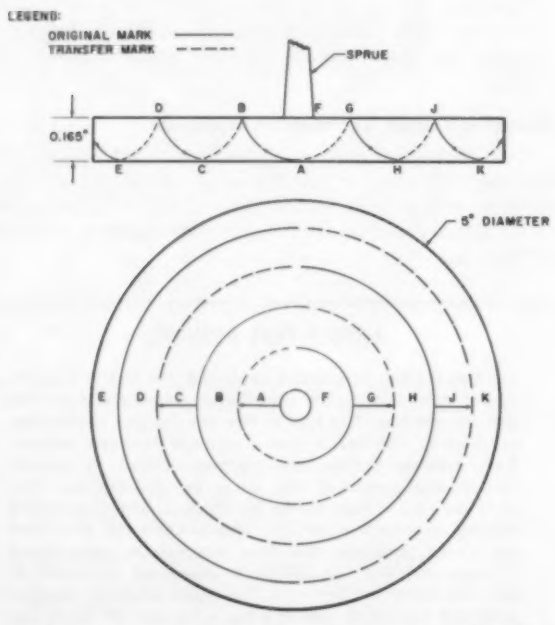


Figure 1. Flat disc was used in studying transfer displacement obtained when both cavity and sprue parts were indexed with red crayon

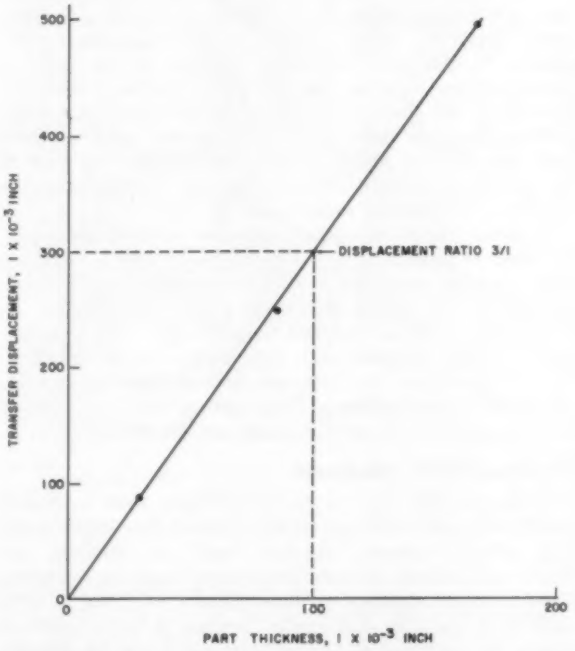


Figure 2. Effect of part thickness on amount of displacement encountered in molding

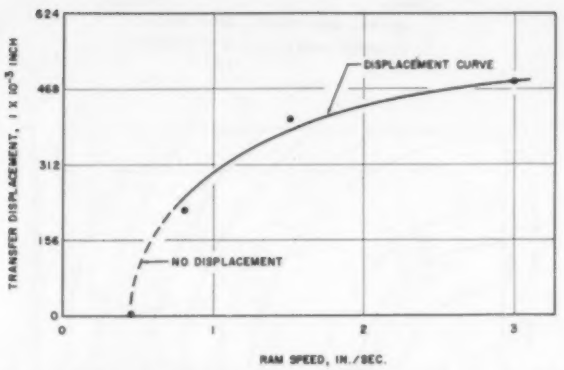


Figure 3. Displacement as related to ram speed. The transfer displacement approaches a constant at higher ram speeds

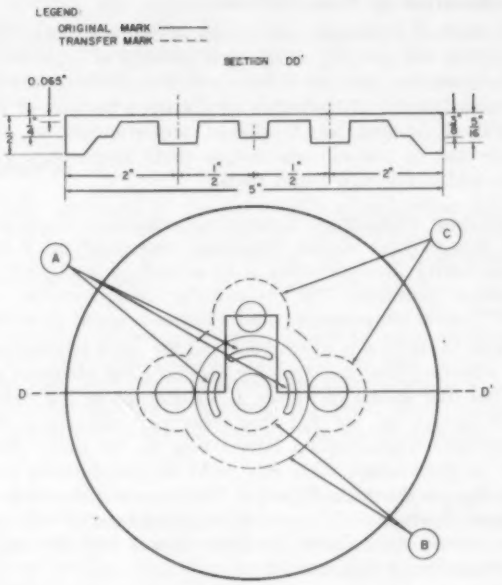


Figure 4. Plastic flow using a three-boss disc

several different processing conditions. Discs were molded over a range of cylinder temperatures from 300°F. to 500°F., mold temperatures from 110°F. to 165°F. and injection pressures from 8,000 to 16,000 psi. All discs molded at these conditions were measured for displacement of the transfer medium.

Results from this investigation disclosed that the displacement of the transfer mark from one surface of the disc to the opposite surface of the disc was fairly constant over the processing ranges studied. The average displacement was approximately three times the thickness of the part. Another factor influencing displacement, the velocity of the material entering the cavity, is discussed in the latter portion of this paper.

The effectiveness of red crayons as transfer mediums were related to mold and cylinder temperatures and were somewhat limited in usefulness at low temperatures, i.e., mold temperatures of 110°F. and cylinder temperatures of 300°F. Of these two temperatures, higher material temperatures were found to be more instrumental in effecting a suitable transfer than elevated mold temperatures.

Effect of Part Thickness on Transfer Displacement—To study the effect of part thickness on the amount of displacement encountered in molding, high density polyethylene (melt index 5.0) was molded on a four-ounce Lester machine using a 45-second cycle, 140°F. mold temperatures, and 350°F. cylinder temperatures.

Part thickness was varied between 0.030-inch and 0.165-inch by placing flat metal disc inserts of different thicknesses in the cavity of the mold. These metal inserts 0.022-, 0.080-, and 0.130-inch thick, produced molded parts of 0.140-, 0.088-, and 0.030-inch thickness respectively. Displacement data obtained on the 0.165-inch thick flat disc were also included in this work.

An analysis of these data indicated that transfer displacement was related to part thickness. The transfer displacement to part thickness ratio was found to be 3 to 1. This ratio which appeared consistently throughout this study, is illustrated in *Figure 2*.

Effect of Injection Ram Speed on Transfer Displacement—The effect of various injection ram speeds on transfer displacement was investigated by molding high density polyethylene (melt index 5.0) into flat discs (0.165-inch thick) on a four-ounce Lester machine using the same conditions used for the part thickness study and varying ram speed.

Data obtained in this study showing that displacement is related to ram speed are illustrated in *Figure 3*. With increasing ram speeds, resulting in increased velocities of the material, the displacement continued to increase. However, as the ram speed increased, the ratio of the ram speed to the transfer displacement appeared to approach a constant.

Continuous reductions in ram speed eventually caused transfer displacement to disappear indicating that the end-over-end flow had given way to some other type of flow. The molten polyethylene advancing through the mold at these low speeds undoubtedly assumed a new configuration characterized by plug flow.

The lack of transfer displacement obtained at slow ram speeds was analogous to results obtained with cellulose acetate and polystyrene. It may now be hypothesized that the lack of transfer displacement obtained with cellulose acetate and polystyrene was not necessarily due to the unsuitability of red crayon as a marking medium but rather because of their plug flow pattern. Under conditions of faster ram speeds producing high velocity flow, it is conceivable that end-over-end flow would be developed with these other materials as well. However, additional work is required to substantiate this proposition (see box describing further studies completed just before press time).

Effect of Density and Melt Index on Transfer Displacement—To determine the effect of melt index and density on transfer displacement, several polyethylene materials with melt indexes from 0.7 to 20.0 and densities from 0.93 to 0.96 were molded into flat discs using the same conditions used above.

Results of this study indicate that transfer displacement of these materials was not affected by melt index and density.

Development of Flow Patterns

To further investigate the merits of transfer tracer techniques for determining plastic flow patterns of high density polyethylene in injection molds, several molds were selected for investigation. These molds were chosen because of their individual designs which offered opportunities to study plastic flow in non-uniform section parts, single-edge gated parts and multi-edge gated parts.

Three-Boss Disc—High density polyethylene (melt index 3.0) was molded in the three-boss disc mold on a four-ounce Lester machine using a 45-second cycle, 12,000 psi. injection pressure, 350°F. cylinder temperatures, and 120°F. mold temperatures, and a fast ram speed (3 in./sec).

Parts made in this mold displayed the same characteristic end-over-end flow and transfer displacement obtained with the flat disc shown in *Figure 1*. In contrast to the uniform cross section of the flat disc, this part contained three bosses which interrupted lateral flow in the mold. Plastic flow as determined with this mold by the transfer tracer technique is shown in *Figure 4*. The top view shown in this *Figure* illustrates the cross-sectional design of the part. The bottom view shows the three bosses and the original and transferred crayon marks.

Several interesting conclusions were drawn from this plastic flow diagram. The areas designated in the diagram with "A" did not transfer as did similar marks in other locations. This erratic flow behavior may be attributed to two opposing plastic paths; one advancing from the sprue to the bosses and one backing up from the partially filled bosses to the sprue, thus promoting non-uniform flow in this area.

Another observation involved the lateral displacement of the crayon mark in the area designated "B" in the diagram. This displacement was 0.180-inch, which is approximately three times the thickness of the part at this point. This supported the results obtained in the case of the flat disc in which plastic flow appeared to be related to the thickness of the part.

A third observation concerned the lateral displacement of the plastic flow beyond the bosses located in the areas designated "C" in the diagram. The displacement at these points was about 0.180-inch. It was noted that if the distance across the boss was subtracted from the total displacement, the 3:1 relationship of displacement to part thickness reappeared. Thus it appeared that the plastic flow resumed its normal flow pattern after completely filling the bosses.

Flow patterns could not be derived in the stepped areas near the periphery of the disc because of the relatively short flow paths from the indexing point to the edge of the disc.

Single-edge (90°) Gated Plaque—High density polyethylene (melt index 5.0) was molded into a plaque (3" x 5" x 0.125") on a four-ounce Lester machine using a 45-second cycle, 12,000 psi. injection pressure, 350°F. cylinder temperature, 140°F. mold temperature, and a fast ram speed (3 in./sec.).

Molded parts showed once again the characteristic end-over-end flow found in both discs. However, in contrast to the sprue-gated discs, the plaque was gated with a half-round gate having a radius equal to the thickness of the plaque. The plastic flow pattern developed with this part is shown in *Figure 5*.

The corner location of the gate promoted non-uniform flow across the plaque as shown by the different degrees of displacement encountered along these edges. The direction of the flow paths and the relative displacement of the tracer marks are designated in this diagram with arrows.

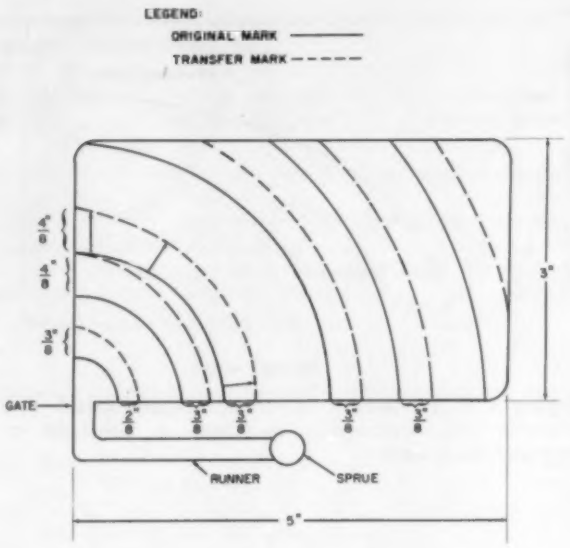


Figure 5. Plastic flow using a single edge (90°) gated plaque

The displacement in the direction of the flow parallel to the gate was slightly greater than that obtained in the transverse direction. This condition of non-uniform flow was maintained until the plastic flow (parallel to the gate) advanced to the point where it reached the opposite cavity wall, at which point it was then directed along the length of the plaque. As the included angle of flow was gradually reduced, the displacement became more uniform.

The primary cause for the formation of non-uniform flow in the plaque may be attributed to the location of the gate which directs the melt stream along the narrow edge of the part. Even if the length of the narrow edges of the part were increased to equal the linear dimensions of the long edges, it is not likely that uniform displacement would develop because of the continued existence of unbalanced flow patterns *(see arrows Figure 5)* from the gate.

It may be predicted from this diagram, that uniform flow could be promoted in this part and other rectangular parts through proper gate modifications. Such modifications would be designed to promote balanced flow paths and uniform displacement by incorporating the use of multiple gates, fan gates or submarine gates.

In contrast to the direct sprue-gated parts previously discussed where uniform flow was experienced, these edge gated plaques promoted non-uniform flow. This condition presents an obvious problem in determining the relationship of displacement to part thickness. Consequently for the purpose of examining this relationship, the displacement obtained along the long edge of the part was used arbitrarily for analysis. Under this condition, the displacement was roughly three times the thickness of the plaque.

The difference between the displacement of the tracer marks on the narrow edge and long edge of the plaque may be attributed to the velocity of the material flowing along these paths. Material flowing parallel to the narrow edge has the greatest velocity thereby promoting the greatest displacement. This also supported the trends previously obtained and described in this paper.

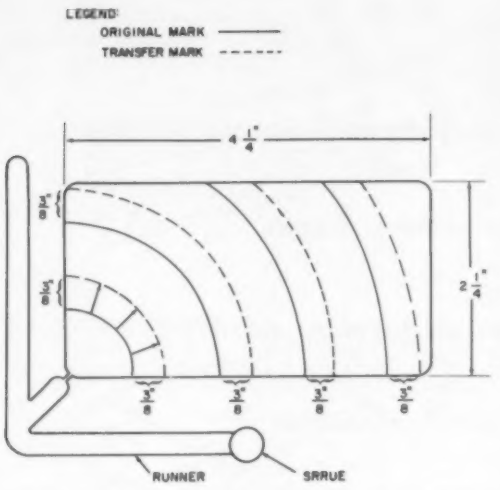


Figure 6. Plastic flow using a single edge (45°) gated plaque

Single-edge (45°) Gated Plaque—To investigate the possibility of promoting uniform flow in rectangular parts through proper location of gates, a smaller plaque (4¼" x 2¼" x 0.125") was selected containing a single gate (0.062" wide x 0.062" long x 0.125" deep). The gate joined the cavity at one corner of the plaque at a 45° angle. As with the larger plaque study, high density polyethylene (melt index 5.0) was molded on the four-ounce Lester machine and at the same molding conditions.

Molded parts again showed the characteristic end-over-end flow found in the other molds. In contrast to the large plaque, however, uniform flow was promoted in this part through proper gate location. The uniform plastic flow pattern developed in this part is shown in *Figure 6*.

This work supported the previous contention that proper gate geometry and location will promote balanced and uniform displacement (see arrows) in rectangular parts. This effect could be obtained with other gate designs as long as they are located in an appropriate manner.

The displacement ratio determined on this part was found to conform to the previously established pattern, i.e., 3 to 1.

Multi-edge Gated Plaque—This part contained five gates located on the narrow edge. All of these gates were 0.125" deep. Gate number 1 was 0.062" wide x 0.062" land length and the remaining gates (numbers 2, 3, 4 and 5) were 0.032" wide x 0.062" land length. *Figure 7* illustrates the plastic flow for this part; arrows denote the direction of the flow paths and the relative displacement of the tracer marks.

High density polyethylene (melt index 5.0) was molded in this mold on a four-ounce Lester machine using a 45-second cycle, 12,000 psi. injection pressure, 350°F. cylinder temperatures, 140°F. mold temperatures, and a fast ram speed (3 in./sec.).

Transfer tracer techniques illustrated that this plaque (4-¼" x 2-¼" x 0.125") also showed end-over-end flow as was the case with the other parts described in this paper.

Uniform flow was more readily obtained in this plaque than previously obtained in the large plaque containing a single gate located at a 90° angle from the long edge.

In general, the uniform and balanced flow encountered in this plaque resulted in a fairly constant transfer displacement of approximately three times the specimen thickness. These results illustrated that uniform and balanced flow can be achieved with multiple gates.

Conclusion

- Results obtained in this investigation and presented in this paper illustrated the merits of employing transfer tracer techniques for determining the nature of plastic flow in injection molds.

- In general, polyethylene was found to have end-over-end flow in injection molds. This type of flow cannot be altered readily through variations in cylinder temperatures, mold temperatures, and injection pressures. However, this type of flow can be altered through ram speed reduction.

- Transfer displacement of end-over-end flow was related to part thickness at ram speeds normally used in production molding. A 3 to 1 ratio of transfer displacement to part thickness was found to exist over a broad range of molding conditions.

- End-over-end flow and transfer displacement were not significantly affected by polyethylene materials varying over a broad range of melt indexes and densities.

- Uniform and balanced flow may be obtained through application of sound gate design principles.

- Application of this technique holds promise for more readily balancing gates and determining proper molding techniques. More articles resulting may have reduced internal stresses and elimination or reduction of such consequent defects as warpage, stress cracking, and surface imperfections.

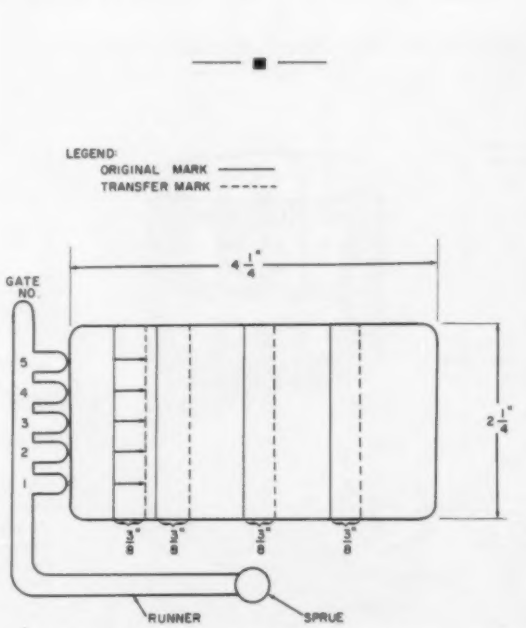


Figure 7. Plastic flow using multi-edged gated plaque (five uniform gates were placed on the narrow edge)

New developments in plastics and processing mean blue sky ideas

can very often be brought down to earth. This short article is designed

Some Blue Sky Packaging Ideas

to motivate processors and end-users into the realization

that no matter how "way-out" an idea might seem, there is a possibility

that it can always be brought down to earth.

Ralph F. Hansen, *Monsanto Chemical Co.*

The greatest single factor in making an idea successful in packaging is convenience. Probably a blue ribbon winner of convenience packaging is a unit being offered by Quaker Oats for Corn Bread Mix. Actually, the package costs more than the ingredients, if bought separately. But the package allows the housewife to mix the batter in a polyethylene bag, then simply empty it into a foil pan for baking and serving. Another winner in the blue ribbon category is Johnson's new shoe polish container now being successfully sold after test-marketing. The container opens easily, has its own urethane foam applicator, and functionally, its own shoe rag for polishing—all in one package.

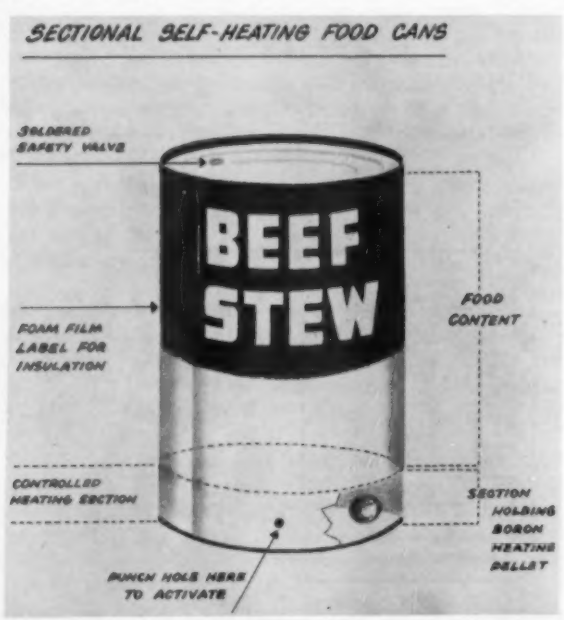


Figure 1. New packaging idea which uses polystyrene foam as insulation Patent Design • R. F. Hansen • 8/16/60

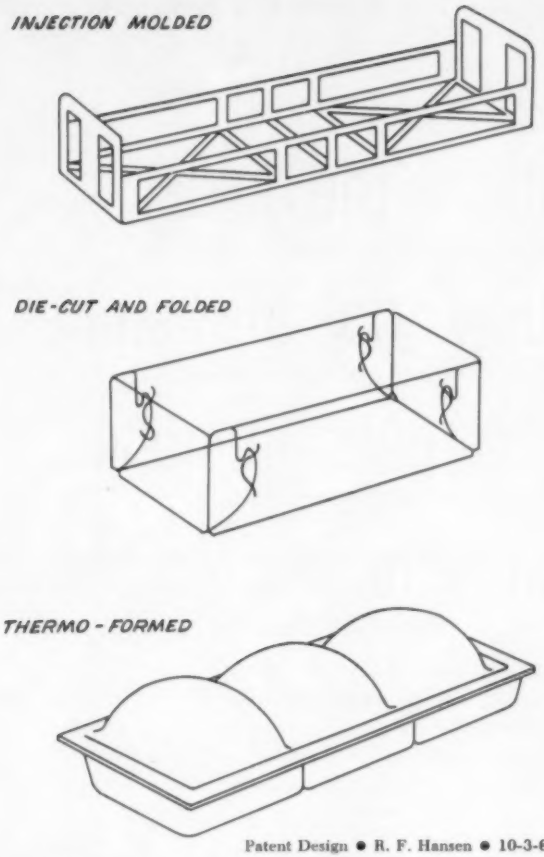
Still in the Idea Stage

Next, consider the photograph of the package of beef stew (*Figure 1*) with its built-in heating unit. The bottom compartment of a 2-compartment metal can is punctured to admit air. This activates the phosphorous compound fuel pellet which gives off just enough energy to heat the stew in its own container. The label is printed on polystyrene foam film, an ideal insulating material to allow handling the heated can for opening and serving. The polystyrene foam insulation can also be used as an insulating label in hot soup vending machines.

Probably the largest market for multiple packaging is the carbonated beverage can. Over 10 billion cans of beer alone will be packaged in 1961. Blue sky idea, simple but effective, is a styrene clip which snaps over the tops of a carry-out six or eight pack, yet holds the package in a firm grip. The cans can be cooled in a tub of ice water without removing the plastic holder yet may be taken out one at a time.

One of the most successful specialized carton-shipper containers is the one made of Fome-Cor, a sandwich of styrene foam between two sheets of waterproof kraft. Ideally suited for the air-age, fresh flowers, with loose ice, are being shipped daily by air freight from California to Chicago, New York and other U.S. cities.

There is continuing interest by manufacturers of consumer goods and food processors in rigid thermoformed containers with flexible transparent film overwraps. The middle sketch (*Figure 2*) indicates a transparent cold fold



Patent Design • R. F. Hansen • 10-3-60

Figure 2. Progression of ideas for container for vegetables or other foodstuffs

Plasti-lok package of oriented styrene. The Jones machine automatically folds and locks the package ready for the consumer product, which is then over-wrapped in transparent film on automatic equipment.

A blue sky idea is the bottom package (*Figure 2*) Slight conversion of a Schjeldahl lidding equipment could make this package a reality. It is a rigid thermo-formed tray container with the lid automatically formed in the shape of the fruit or contents.

Another highly successful in-line package is the squeeze bottle or blown bottle made of polyolefins. Production is now running around a billion units annually and the versatility of the plastic material gives promise of many new innovations, the newest being the Plax-Corporation-blown ½ gallon jug with an easy lift and pour handle.

Consider Carbonated Beverages

Some day in the future, carbonated beverages will be packaged in throw-away, blown plastic containers. Designed in plastic, such a container could have some functional values, such as an easy drinking lip, and also be very attractive (*Figure 3*).

Disposable Servers

Referring to convenience again, there is the possibility of the homemaker's preference for the throw-away plastic cereal bowls, in the multiple unit package (*Figure 4*). Foamed styrene laminated to sheet styrene then formed into picnic plates is now a reality, with prices similar to paper plates.

Some of these ideas may be so "far out" they're completely out of the ball park. However, the purpose of this article is to stimulate ideas.

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Figure 3. Possibility of the future for packaging soft drinks in plastic blown containers

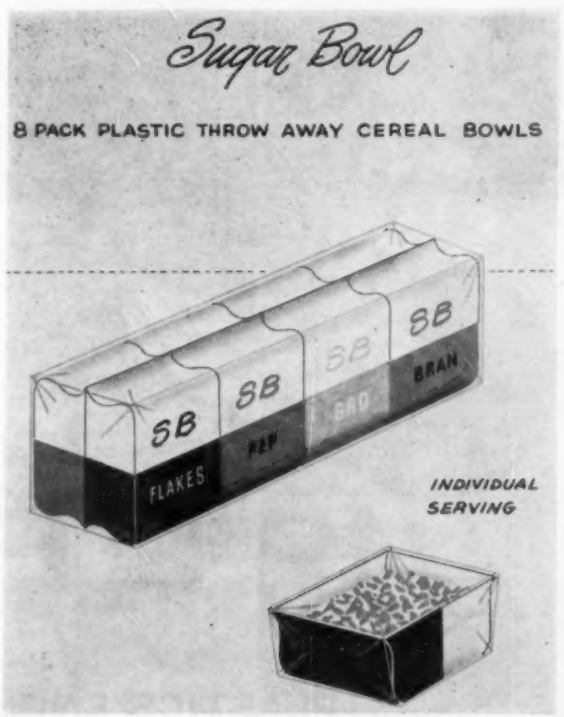

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Figure 4. Throw-away cereal containers

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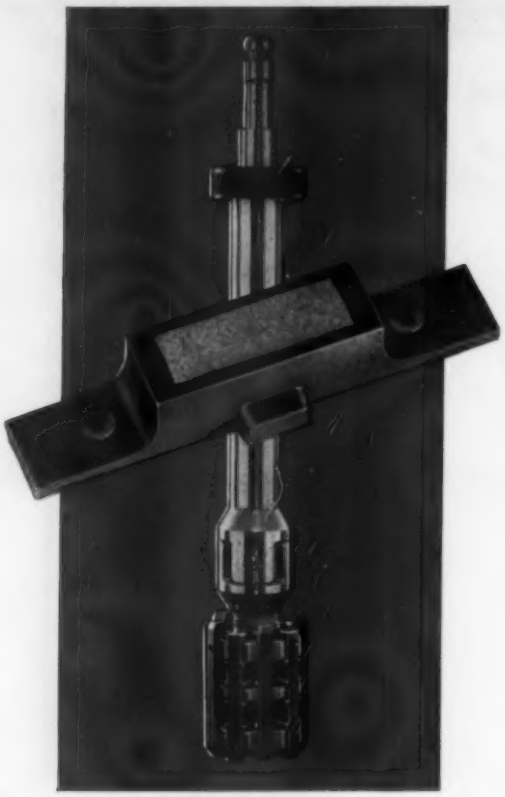


this is the holder

(MOLDED WITH PHENOLICS)

that grips the "stone"

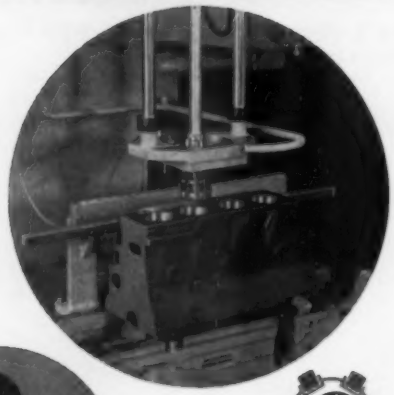
(THE ABRASIVE CUTTING-SURFACE)

that puts the hone

(THE ULTRA-PRECISION TOOL)

in Micromatic Microhoning

(THE CONTROLLED ABRADING PROCESS)



Into the hardest of case-hardened steels bite the abrasive cutting-surfaces used in the modern *Microhoning* process of controlled abrading. Into soft plastics, too, brittle ceramics, even glass. Control is so positive, technique so perfected, and results so precise that geometric tolerances to within .0001 of an inch are obtainable.

Developed by Micromatic Hone Corporation, Detroit, Mich., Microhoning provides one of the most efficient methods devised for the removal of stock from both internal and external cylindrical surfaces.

One key to this high precision automatic honing process is the abrasive stone in its molded holder. When *Plenco* phenolics are specified as the molding material they are chosen on the basis of the compound's adaptability to a wide range of abrasive grades, and—most importantly—its uniform flow and *uniform shrinkage*. Such assured dimensional stability is essential. Because the holder must fit and hold the abrasive securely and precisely. In addition, any deformation in the molded casing must be minimal and predictable, since its outer perimeter is used in some Microhoning cycles as a gage to maintain correct size of the work.

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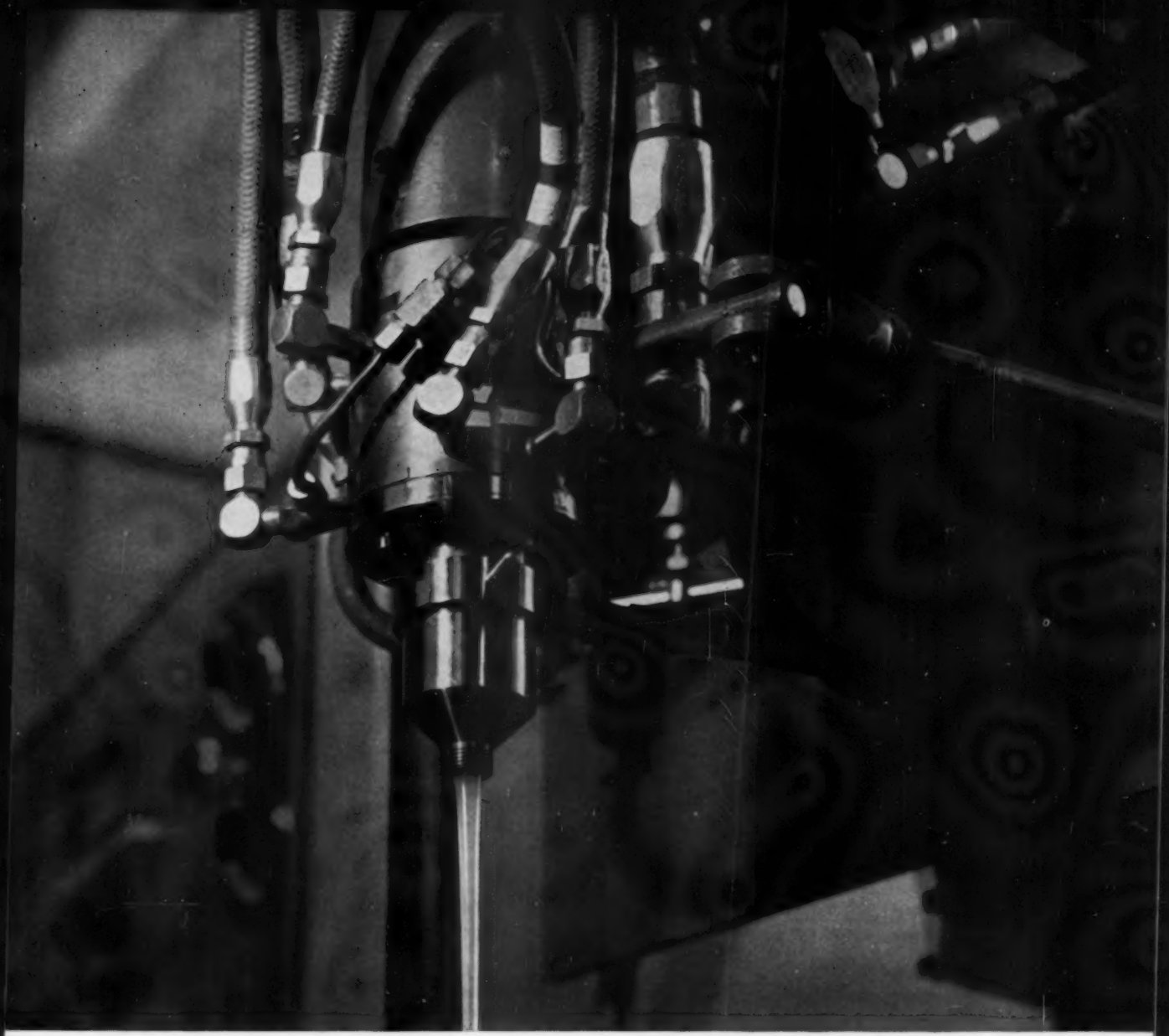

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SOCIETY ACTION

On the front of the medal, the SPE emblem in red is super-imposed on a globe signifying the international scope of both the Society and the Award. Around this globe are depicted four major segments of plastics science and engineering—theory, research, production of resin and processing of plastics materials. Theoretical aspects are represented by a molecular model; research by a flask, test tube and schlieren waves; and resin production by towers of monomer and polymer plants. Plastics processing is portrayed by a symbolic equipment composite producing a plastics sheet from molding resin.

The medal is of gold, three inches in diameter by one-quarter inch thick. It was designed by Dr. Alex Sacher and the design executed by Carl Ludwig Schmitz, internationally renowned sculptor.

New Society Award to Honor Outstanding International Plastics Engineer

Frederick C. Sutro, Jr.

Chairman, Past Presidents Advisory Board (Cabot Corporation)

One of the major responsibilities of an engineering society is recognition of outstanding contributions to the technology of its particular segment of the scientific or engineering world. In SPE the need to acknowledge these accomplishments has long been recognized, but it has not been until recently that such an Award program has been formalized. As an initial step, the President's Cup was established in 1957 for outstanding and meritorious administrative service to the Society and the first award made at the 14th ANTEC in Detroit in 1958.

It was not until this year, however, that the Society was able to provide a means of recognizing and paying tribute to an individual for his contributions to the technology of plastics science and engineering. Thus, the establishment and implementation during 1961 of an International Award in Plastics Science and Engineering has become a significant milestone in SPE annals.

The International Award was formally established at the January 25, 1961, Council meeting to achieve the following objectives:

1. to stimulate and encourage fundamental contributions to plastics science and engineering throughout the world
2. to acknowledge outstanding achievements by honoring the distinguished scientists and engineers who make them
3. to disseminate the technical information of Award Lectures widely among plastics scientists and engineers.

This Award for "fundamental and outstanding contributions in plastics science and/or engineering" will be presented for the first time at the 18th ANTEC at Pittsburgh in early 1962. It comprises a gold medal (see photo), certificate, cash honorarium ($1000 the first year) and a nominal travel allowance, if requested by the recipient. An integral part of the Award is a lecture by the recipient in the specific technical area for which the Award is made. The lecture will be delivered at the ANTEC at which the Award is presented.

The Award may be presented annually, although it is possible that in some years a recipient may not be selected. The recipient will usually be one individual, except under very unusual circumstances in which more than one person may be selected. The Award is made without regard to sex, age, nationality or membership in SPE.

The idea of the Award originated with SPE's New York Section which developed it as a memorial to a former member, the late Herbert Preiss. Aware, however, of the need of the Society for a major Award and in an effort to enhance its prestige among scientists and engineers worldwide, the Section generously turned over its administration to the international Society. As its continuing contribution, the Section will sponsor the gold medal, designed by Dr. Alex Sacher, chairman of the New York Section Committee who developed the Award. All other costs will be borne by the Society through the medium of its annual budget.

Administration of the Award, like that of all other SPE honors, is a function of the past Presidents Advisory Board, composed of all living SPE Past Presidents. Nomination of candidates and collection of data and other material for consideration by the Award Committee is handled by a Canvassing Committee, a nine member group. Actual selection of the recipient is made by an Award Committee, also consisting of nine members, four of whom are from countries other than the United States. Terms of members of both committees are staggered so that only one-third of the members are replaced annually. Members of both Committees are appointed by the SPE President upon the recommendation of the Past Presidents Advisory Board.

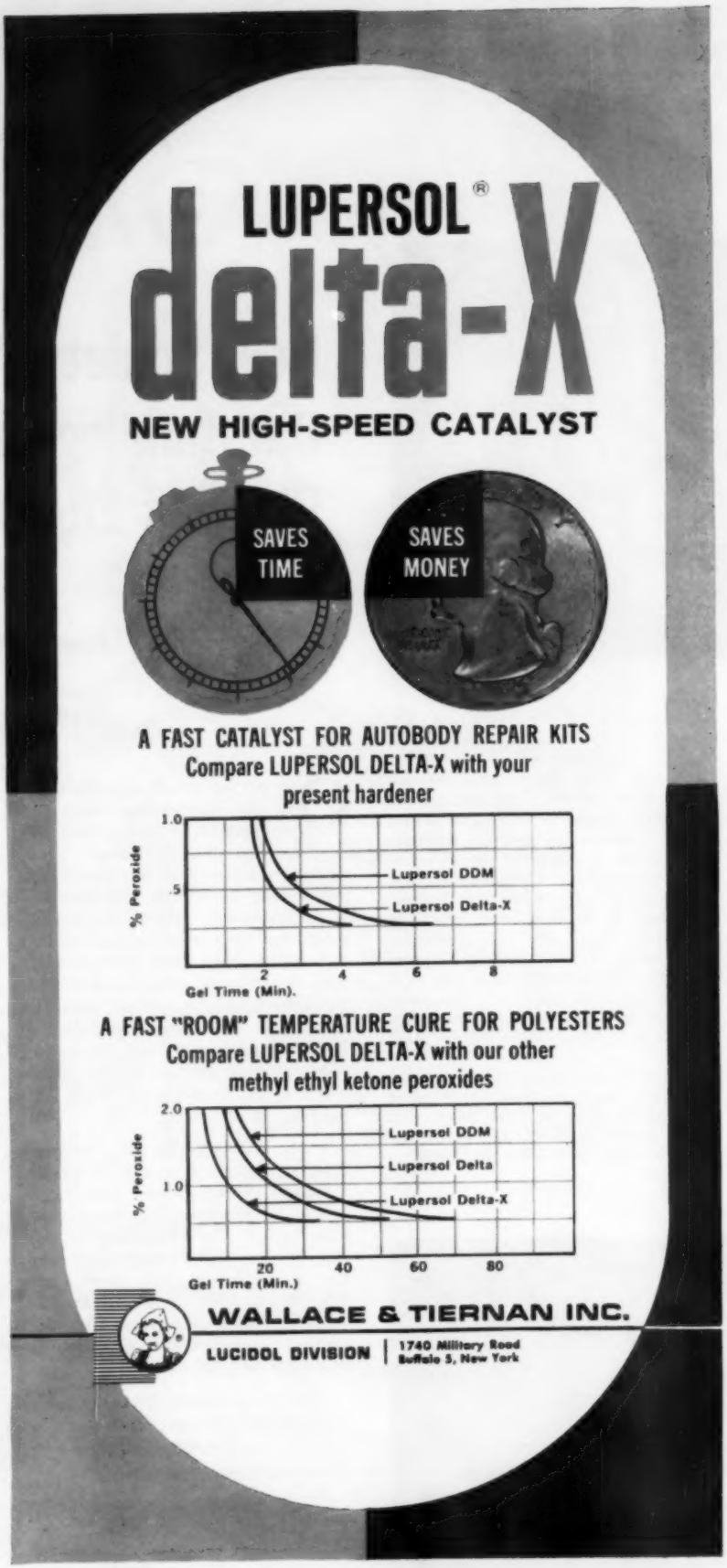
The Canvassing Committee for the 1961 Award has been chaired by William O. Bracken, SPE President in 1952. This year most nominations were made by this Committee, although any SPE member may nominate candidates. In subsequent years, nominations for the Award will be requested from members and solicited in the SPE Journal.

Chairman of the 1961 Awards Committee is Dr. Gordon M. Kline of the Baltimore-Washington Section. At present, balloting has been completed and the recipient, who is now preparing his Award lecture, will be announced at the 18th ANTEC.

Rules for administration of the SPE International Award have been carefully documented by Council and are included in a recently published brochure detailing the Award. Copies of this brochure are available to SPE members upon request from the Executive Office.

—— ■ ——

edited by **Thomas A. Bissell,**
SPE Executive Secretary



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Laurence R. Sherman
Vice-chairman, Coloring of Plastics PAG
(Imperial Color Chemical & Paper)

PAG Progress

Newest PAG to Develop and Coordinate Plastics Color Technology

A new Professional Activity Group was born during the past year, the Coloring of Plastics PAG. Formal meetings have already been held and this PAG is now functioning with elected officers, executive and working committees.

There are two important points about color in plastics. First is the tremendous plus value of color, when available and perceptible, or the lonely void created by its absence. The second is the fact that it is very difficult to substitute the spoken word for the psychological and stimulating effect of color.

Since there is a considerable body of literature on the subject of color and its application, one of the most logical projects of the new PAG is to prepare a selected bibliography from which a handbook can then be prepared. Pertinent literature is now being collected by members of the Group.

Knowing the "color language" can have important economic benefits. For instance, it is important to know the difference between a dye and a pigment. Such information must be conveyed to processors, vendors, or compounders, so that metals, fabrics, coatings, plastics, and other surfaces can be harmoniously blended into economically useful articles. There is a demonstrated need for a uniform color language. This new PAG will work on projects related to achieving this.

Color must be understood in its three dimensional concept, and if the human eye is to be complemented by color-measuring instruments, these human and "inhuman" tools must be correlated. Human perception of colored surfaces is a psychological integration of hue, brightness, gloss, haze, changeability, transparency, richness, and clarity, with accompanying compensation for differences in smoothness or continuity of surface, whereas instruments measure only some physical response, probably electrical.

To illustrate, consider what happens when one remarks that a color is lighter than it should be. If it is accepted that the three dimensional concept of color is basic and that the Munsell System is a widely known and workable method of analyzing color, the interpretation applied to that analysis might indicate a color adjustment opposite to that intended. Suppose the interpretation indicates a deficiency in Value or a higher position on the grayness scale, then black would be added to adjust. But if the analysis indicated "lighter" because of a deficiency in Chroma, adding black would be completely unsatisfactory.

Color vision in humans varies among individuals. Furthermore, since interpretation is a psychological and subjective experience, it is difficult to train people to be objective in their evaluation of color, and it is even ridiculous to expect untrained people to adopt such an approach voluntarily.

Another problem area upon which the new PAG will focus attention is Metamerism—colorants must be identical if two samples of one material are to look alike under all illuminants. The PAG will attempt to develop uniform viewing conditions, sound specifications and standards in this field.

The Coloring of Plastics PAG will also be concerned with processing problems since the colorants must be compatible with the resins being colored. The PAG should become a clearing house for such processing information. In the area of information, there is already a team working on a group of papers to be presented at the 18th Annual Technical Conference (ANTEC) in Pittsburgh, this coming January.

Other developments include a Regional Technical Conference (RETEC) on color to be held in Rochester on April 12, 1962 and coordination of this PAG's program with the Inter-Society Color Council.

The stated goals of this PAG will not permit early completion, for the problems are complex and numerous. However, those who have guided the Coloring of Plastics PAG this first year know that a strong and useful PAG will emerge.

—— ■ ——

Edited by **Saul Gobstein,** *Chairman PAG Executive Committee (Ferro Chemical)*

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Celanese stabilized formaldehyde can be transported and stored at temperatures a full 15 to 30 degrees lower than previously possible.

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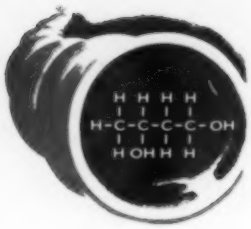

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PLASTICS AROUND THE WORLD

This month's column has been made possible through the contribution of these abstracters:

Hans Mayer (Industries des Plastiques Modernes). Hugh O. Pierson (Pensez Plastiques et L'officiel des Matieres Plastiques)

Leonard Buchoff (Materials in Design Engineering)

Hugo O. Weinstein (Revista de Plasticos)

Geza Gruenwald (Kunststoff-Rundschau)

Spain

REVISTA DE PLASTICOS

MAY-JUNE 1961

Present Techniques in Injection Molding (Part I)—Author: R. Anguita, pp. 159-168

This part of the article refers to operation variables, quality of molded articles in injection molding and different types of equipment used in the technique of preplastification.

Included are two tables for troubleshooting and comparison between conventional and preplasticized injection. There are ten sketches of injection machines using piggy-back screw preplasticizer, in line plunger type reciprocating screw and different heating cylinder arrangements.

Germany

KUNSTSTOFF-RUNDSCHAU

MARCH 1961

Fabrication of Polyolefins—Author: Hans Domininghaus, pp. 107-111

The author describes in a few words, but with the thorough backing of all pertinent literature and patents (83 references), the processes for joining polyolefin parts. He puts most of the emphasis on all the welding methods. The article closes with a few remarks on machining polyolefins.

JUNE 1961

Mixing of Thermoplastics— Author: Alfred Romanowski, pp. 274-280

The author describes mixing, homogenizing, and plasticizing equipment which either work batch-wise or in a continuous production. A few microphotographs illustrate the common procedure for checking the mixing efficiency on carbon-black filled compounds.

Properties and Processing of Microcrystalline Nylon 6—Author: H. Waltersperger, pp. 265-274

Many pictures (microphotographs) and tables compare the significant difference obtained in the crystalline structure of molded Nylon 6 parts, when the special nylon grade, Grilon A30GM, is molded as opposed to conventional resins. Although the article does not describe the method by which this change is evoked, it illustrates the better flow and the decrease in internal stresses in those molded parts.

JULY 1961

Alkalinity of Glass Fibers—Author: Hans Weisbart, pp. 321-326

Though no experimental results of the destructiveness of the extractable alkali on plastics are given, the author puts emphasis on the determination of the extractable alkali in glass fibers. This must not at all be related to the absolute alkali content of the glass, but will depend much more on the balance of all other oxides. Several tables show the results of titrated alkali and electro-conductivity on aqueous extracts of glass fibers of different compositions.

France

PENSEZ PLASTIQUES

APRIL 1961

Plastic Insulation of Electrically Conducting Coatings—pp. 31-32

Aluminum or lead oxide can be deposited on glass plate to provide an electrically conducting coating. This coating must be insulated as well as protected from mechanical deterioration. This can be accomplished by organic coatings such as polyamide-based or polyester-based varnishes. When high temperature properties are required a polyorganosiloxane resin is used.

Polypropylene, Part I—Author: M. G. Douglas—pp. 27-25

Stereospecific catalysts are capable of polymerizing olefins along given spatial configurations. Polypropylene is the best known example. Its strength properties are excellent: of interest is the relationship between molecular weight and physical properties, and between crystallization and other parameters with impact strength. The mechanism of polymerization is explained, including a detailed description of the chemical processing.

JUNE 1961

Polypropylene, Part II—pp. 7-10

In the second part of this study, injection molding of polypropylene is described with emphasis on speed, pressure and temperature of the injection process. Outlined too, is the shrinkage problem, and the relationship between molding temperature and properties of the molded product. The extrusion of films and sheets is also described.

L'OFFICIEL DES MATIERES PLASTIQUES

JUNE 1961

Low Pressure Laminates—pp. 485-491

Low pressure laminates use solventless resin which requires pressure no higher than 350 psi. Such low pressure permits the use of simple and cheap molds such as of wood or plaster. Three major resins are used: polyester, phenolic and epoxy. Reinforcements are mostly in the form of glass fibers. A comparison of the physical properties of the laminates made from different resins is included. Molding techniques are described, including a continuous molding process for glass reinforced polyester panels.

The Preparation of Polyvinyl Chloride—Author: Jean Delorme —pp. 475-477

The most common polymerization technique of PVC is emulsion

(Continued on page 1119)

TECHNICAL MEETINGS CALENDAR

1961 REGIONAL TECHNICAL CONFERENCES (RETEC)

October 25—Plastics in Major Household Appliances sponsored by Kentuckiana Section, Monogram Hall, Appliance Park, Louisville, Ky, Chairman: Ray E. Eshenaur, c/o General Electric Company, AP-5-249, Appliance Park, Louisville, Ky.

November 2-3—Plastics in Packaging and SPE Southwestern Packaging Exhibition on November 1, 2, 3. RETEC sponsored by North Texas Section and Exhibition by Section with cooperation of Southwestern Division Chapter, Society of Packaging and Handling Engineers, Sheraton-Dallas Hotel, Dallas, Tex. Chairman: Peter W. Kent, 3637 Mid Pines Drive, Dallas 29, Texas.

November 15—Vinyl Plastics in the Household sponsored by New York Section with cooperation of Vinyl Plastics PAG, Statler Hilton Hotel, New York, N.Y. Chairman: Saul Gobstein, c/o Ferro Chemical Co., Box 607, Emerson, N. J.

December 1—Plastics Screw Injection Molding sponsored by Cleveland Section, Cleveland Engineering Society Building, Cleveland, Ohio. Chairman: Edward J. Haskins, c/o Injection Molders Supply Co., 17601 South Miles Road, Cleveland 28, Ohio.

ANNUAL TECHNICAL CONFERENCES (ANTEC)

January 30-February 2, 1962—18th ANTEC, Penn-Sheraton Hotel, Pittsburgh, Pa. Sponsored by Pittsburgh Section. General Chairman: John E. Parks, H.P.M. Division, Koehring Co., 512 Empire Building, Pittsburgh 22, Pa.

HIGH SPEED TESTING

October 26-27—Third Annual Symposium on High Speed Testing, sponsored by Plas-Tech Equipment Corp., Hotel Somerset, Boston. Chairmen: Alfred G. H. Dietz, Massachusetts Institute of Technology, and Frederich R. Eirich, Polytechnic Institute of Brooklyn.

CORROSION CONFERENCE

October 30-November 2—Houston; November 27-December 1—Miami; Plastics to Combat Corrosion will be covered at these regional conferences of the National Association of Corrosion Engineers.

BULKS SOLIDS HANDLING

October 17-18—Bulks Solids Handling Symposium of the American Society of Mechanical Engineers. Pick-Nicollet Hotel, Minneapolis, Minn.

BRI CONFERENCE

November 28-30—1961 Fall Conference of the Building Research Institute. Mayflower Hotel, Washington, D. C. Chairmen: Prefinishing, W. E. Kemp, Koppers Co. Performance of Plastics in Building, D. R. Grey, Dow Chemical Co. Mechanical Fasteners for Wood, J. Godley, Gregory Industries. Design for Nuclear Age, G. H. Albright, Pennsylvania State University. Identification of Colors of Buildings, M. D. Folley, Sargent-Webster-Crenshaw & Folley. Methods of Building Cost Analysis, C. Bogart, A. T. & T.

REINFORCED PLASTICS

February 6-8—SPI Reinforced Plastics Division, Technical Conference, Edgewater Beach Hotel, Chicago.

Packaging Conference and Exhibition

Regional Technical Conference Sponsored by the North Texas Section

November 2 and 3, 1961, Sheraton-Dallas Hotel, Dallas, Texas

The complete technical program announced by the Program Chairman James A. Gibbons, Union Carbide Plastics Co., follows:

Recent Extrusion Developments for the Packaging Industry
Charles L. Conley, Jr.
The Black-Clawson Co.

Continuous Non-Contacting Measurement and Automatic Control for Plastics Sheet and Film Extruders
G. R. Gerhard
Industrial Nucleonics Corp.

Factors Affecting Packagability in Polyolefin Containers
Robert J. Martinovich
Phillips Chemical Co.

Injection Parison Blow Molding
Ernest P. Moslo
Moslo Machinery Co.

Present Uses and Future Horizons for Packaging with Thermoformed Acetate
W. M. Roynayne
Celanese Plastics Co.

Consumer and Industrial Skin Packaging
F. C. Steng
Union Carbide Development Co.

A New Extruded High Gloss Rigid Vinyl for See-Through Packaging
E. P. Patty
Nixon-Baldwin Chemicals Co.

Polyethylene Film For Packaging
R. C. Johnson
The Dow Chemical Co.

Plastics Foam Packaging
E. Hamilton Swazey
Lone Star Plastics Co.

Printing or Decorating Plastics
Sumner W. Raymond
Markem Machinery Co.

Approaches to Packaging
Jack Bloch
Loma Industries, Inc.

Packaging Materials and the Food and Drug Act
S. D. Fine
District Director (Dallas), Food and Drug Administration

Recent Developments in Reinforced Plastic Films
Johan A. Bjorksten and William D. Cameron
Bjorksten Research Laboratories, Inc.

Luncheon speakers at the Conference will be Glenn T. Pitzer, President of The Visking Co. and Frank W. Reynolds, 1961 President of the Society of Plastics Engineers, who will speak on progress and goals of the Society.

Requests for further information and advance registration should be directed to:

R. Wayne Kistler
RETEC Registration Chairman
c/o The Koppers Co.
2509 West Berry St.
Fort Worth, Texas

Companies which will participate in the Exhibition include: Flex-O-Glass, Inc.; Continental Plastics of Oklahoma; Nalle Plastics, Inc.; Enterprise, Inc.; West Coast Plastic Distributors, Inc.; Lodlow Corp.; Plasti-Vue Mfg. Co.; Tommy Tucker Plastics; Service Engineers, Inc.; Loma Industries, Inc.; Delaware Barrel and Drum Co.; Texas Plastics, Inc.; Koppers Co., Inc.; Accurate Box & Finishing Co.; Felvey Container Corp.; C & C Manufacturers & Distributors, Inc.; Monsanto Chemical Co.; Magnolia Carton Div., Fleming & Sons, Inc.; Visking Co.; Frankston Paper Box; Bunn-Staton Printing Co.; and General Packaging Corp.

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NEW BOOKS

GLASS FIBRE REINFORCED PLASTICS

by A. De Dani (Interscience Publishers Inc., New York, 296 pp., $9.75)

Mr. De Dani, the Advisory Editor, has presented here a fine cross-section of the materials, processes, and problems associated with the manufacture of glass fiber reinforced plastic products.

An excellent introduction is presented on glass fibers in the various forms available, as well as the types of sizes and finishes that are applied to the glass fiber. The resins covered are polyester—the greatest emphasis is placed on this category because of their wide utility;—phenolic, furane, melamine, and epoxy resins are dealt with in a very limited fashion. A chapter is devoted to the silicones and their uses. A limited but adequate coverage of the accessory chemicals, reactive monomers, catalysts, release agents, and accelerators is also presented.

The greatest value of this publication is the well presented description of the various molding methods and techniques used in the glass fiber reinforced plastics industry. Among those described are the hand layup process, the low pressure molding operation and the various procedures that can fall under this general heading, high pressure molding and the various methods and materials that are used in the high pressure moldings procedure. The book is strongly slanted to the processes that are used in Great Britain which may account for the complete absence of filament winding process and material. The book presents much physical and mechanical data, but the values shown are on the conservative side.

This publication will prove a worthwhile source of information on the whole subject of glass fiber reinforced plastics. It covers the raw materials necessary to produce the products, the various molding methods and some of their problems, a description of the jigs and tools that are used, the finishing procedures that are necessary, and data on the properties that can be derived. Further, recommendations are made on plant requirements to produce these products as well as the laboratory that would be a necessary adjunct of such a plant.

Considering the scope of the subject matter, and allowing for the fact that many important areas could only be touched upon lightly, the author and his contributors have done a creditable job in presenting, in one volume, the whole story of the manufacture of glass fiber reinforced plastic products.

Robert Steinman

PLASTICS INTERNATIONAL

(Temple Press, London, 1961, pp. 478, $9.00)

This book is a registry of suppliers of plastics equipment and materials throughout the world. Rather than just names, addresses, and nature of businesses alone, pictures and descriptions of product lines are featured. Not every manufacturer is included, though, especially among the material suppliers. Names and addresses of British plastics processors and additive suppliers, an international bibliography of plastics books, and lists of world plastics societies and trade journals are also found making the book valuable to those engaged in foreign plastics trade.

The book is well organized and easy to use, with the listings brief, general and with fairly reliable specifications given on the products. The contents are devoid of critical comment on the products. It rather looks as if the suppliers have been quoted verbatim. Their relative size and importance are hard to determine, and no price information is given.

Coverage of United States firms is fairly good in equipment, but deplorable in materials. For example, duPont is not listed among U.S. nylon suppliers, Goodrich is omitted for vinyls, Shell is left out for epoxies and no U.S. polypropylene suppliers are named at all. Furthermore, distinction is seldom made between prime producers and resellers/compounders. The book should have been edited by experienced, impartial people, and it is hoped that this will be done for future editions.

The equipment section is considerably better with more pictures of the various machines used. Throughout the book, there is extensive listing of sales representatives and licensed manufacturers all over the world. Considerable advertising makes the book resemble a big magazine, somewhat, but the advertisements are placed in separate sections and the text is uninterrupted.

Allan L. Griff
Union Carbide Plastics Co.

RADIOISOTOPES APPLICATIONS ENGINEERING

by Jerome Kohl, Rene D. Zentner and Herbert R. Lukens (D. Van Nostrand Co., Inc., Princeton, N. J. 1961, 562 pp., $16.50)

Quite a few books have been published during the past ten years on the multiple applications of radioisotopes. Many of them are more or less specialized in a particular field and thus highly contribute to the advancement of tracers applications. A few others are but compilations of previous works. This book is specialized enough in a few fields, but also gives the fundamentals which the neophyte in this science will be glad to find.

The first chapters deal with the elementals of radiation physics, the production of radioisotopes, the detection of radiations and their measurement and other fundamental aspects. The uses of radioisotopes are described in the second part: flow and leakage, radiography, friction and wear, specific gravity and engineering applications. In chapter 14: Process Uses of Radiations, the SPE JOURNAL readers will find eleven pages of the greatest interest. The applications of ionizing radiation on plastics and elastomers are described in detail: production of polyethylene, polymerization of styrene, graft polymerization, cross-linking of nylon, polyvinyl derivatives, polyacrylates, degradation of plastic packaging materials by irradiation. Cross-linking in the curing of rubbers is described. A photograph shows the experimental vulcanization of a tire by means of Cobalt 60. The last part of this sub-chapter concerns the use of radioisotopes on petroleum, solvents, catalysts and other chemicals. The third part of the book consists of several appendixes which give a great deal of additional information.

Dr. Louis C. Barail,
Barail Associates

(continued from page 1115)

polymerization, using sodium persulfate or hydrogen peroxide Preparation of the aqueous phase is described, followed by a description of the polymerization process.

INDUSTRIE DES PLASTIQUES MODERNES

JUNE 1961

A Survey of the thermal degradation of Polyvinyl-chloride.—Author: A. Guyot and J. P. Benevise

An examination of the macromolecular products resulting from thermal treatments of polyvinyl-chlorides shows an increase in the weight of the individual molecules and a preponderance of heavy molecules. The thermal treatment consisted of blending, calendering, mixing etc. under heat conditions similar to these applied in production processing. This change has practical ramifications when polyvinyl-chlorides are subjected to a sequence of such exposures in the course of a production cycle.

USSR

VYSOKOMOLEKULIARNYE SOEDINENIIA

MARCH 1961

The Role of Chemical and Intermolecular Bonds in Polymer Rupture.—Authors: S. N. Zhurkov and S. A. Abasov, pp. 450-55

The change in the time-temperature relation of the strength of viscose, capron and polyacrylonitrile fibers was investigated as a function of orientation and plasticization. The strength of polymer fibers is associated with rupture of chemical bonds.

Time Temperature Dependence of Strength of Polymer Fibers.—Authors: I. S. N. Zhurkov and S. A. Abasov, pp. 441-49

The time-temperature dependence of the tensile strength of viscose, capron, polyproyplene, nitrile and chlorovinyl fibers was investigated over the temperature range/+150 to −120°C. An activation mechanism of polymer rupture is a process developing in time under the action of temperature and mechanical stress.

APRIL 1961

Carbochain Polymers and Copolymers. XXXII. Graft Copolymers with Thiodivaleric Acid Side Chain Residues.—Authors: H. S. Kolensnikov and Tsen Khanmin.

Graft copolymers were obtained by reaction of polymethylmethacrylate with polyethylenethiodivalerate and mixed polyesters containing besides thiodivaleric acid residues, the residues of adipic, azelaic and sebacic acids. The properties of the resultant polymers were investigated. Regularity in the graft copolymers increases with increase in the number of hydrocarbon atoms in the dicarboxylic acid. In the mixed polyesters obtained from thiodivaleric and adipic acids and ethylene glycol, spherulites of ordered macromolecular packets and of monocrystals were revealed.

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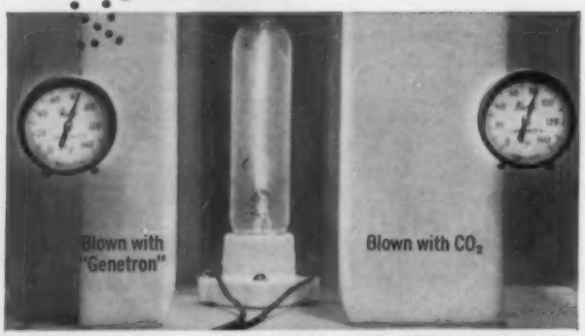

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ABOUT MEMBERS

J. R. Freyermuth, president of Northwest Plastics, Inc., St. Paul, has announced the purchase of Hermitage Plastics of Nashville, Tenn. by his company. Hermitage is a producer of miniature electrolytic condenser enclosures and a leading manufacturer of seamless tubing by the spin molding process.

Announcement was made of the appointment of **J. Thomas Selldorff,** formerly group supervisor of applications for The Kordite Co., a division of National Distillers and Chemical Corp., as product manager of polypropylene film for Shorko, Ltd. Mr. Selldorff is a chemical engineering graduate of Cooper Union and holds a M.S. in industrial management from M.I.T.

John R. Kent has been appointed a technical service specialist for Monsanto Chemical Co.'s Plastics Division. He holds an M.S. in industrial engineering from Columbia University and has served as a member of the technical staff of the Lustran Task Force at Springfield. Mass. Further announcements name **Stanley R. Melvin** a technical service specialist for the Plastics Division marketing department at Springfield. Mr. Melvin, who has a B.A. in chemistry from Stanford University, '42, served as a member of the technical staff of the Lustran Task Force. **Alfred J. Roche** was designated assistant product sales manager, Lustrex. Mr. Roche, who has a B.S. in chemical engineering from the University of Detroit, served as senior sales representative for the division in the St. Louis district office. Also joining the plastics division at Springfield in the research department is **J. Kenneth Lund** who has a M.S. in plastics engineering from Princeton ,'58.

Emery has released news of recent staff movements. **Joseph E. Quinty** Chicago sales manager is now assistant sales manager of the Organic Chemistry Division in which capacity he will assist in the marketing of plasticizers, organic acids and jet engine lube bases. **R. S. Haley** who has been promoted to the position of the Vopcolene Division on the West Coast obtained a B.S. in chemical engineering from the University of Pennsylvania three years ago.

Horst Oekinghaus, vice chairman of the Arizona section, SPE, joins the administrative staff of one of the five Northwest Plastics plants. He was general manager of J-B Electronics, Inc. Mr. Oekinghaus attended the Universities of Bonn and Hamburg (Germany).

Amoco Chemicals Corp. has announced the appointment of **William F. Christie** as eastern representative, market research and development. He will be located in the company's New York City office. With the company since 1958, Mr. Christie was most recently director of market research. He holds a B.S. degree in chemical engineering, University of Michigan, '42.

Shell Chemical Co. has made known promotions and transfers reflecting the company's expansion in the plastics field. **R. M. Maybee** has been named manager, Plastics Technical Service at the laboratory, Union, N. J. **V. O. DeCoster** will assist him as supervisor, technical service-olefins. **F. T. Watson** has joined the laboratory staff as a senior technologist, and on the district sales staff as supervisor of district sales-resins is **P. H. Teliha,** Central District (Chicago). **R. S. Davis,** formerly a technical salesman in the Central District joins the head office sales development resins product group as a technologist.

William I. Steele has joined J. D. Robertson, Inc., to provide additional sales engineering and technical service on the plastics molding presses and other equipment made by F. J. Stokes Corp., the principal firm Robertson represents in the Southeast. Mr. Steele has been associated with Koppers Co. and Rohm & Haas Co. and is a 1948 chemical engineering graduate of Georgia Tech.

Named Marlex sales representative in the southern district of Phillips Chemical Co.'s plastics sales division is **J. L. Jacoby.** He has been with the firm since 1951, and is a graduate of Oklahoma State University.

Peter Blom has been appointed as a sales engineer for the entire product line, Flexible Products Co., in order to implement customer sales service of the recently expanded operation.

AviSun Corp. has announced the appointment of **John D. Cruikshank** as senior process engineer for the film plant at New Castle, Del. Mr. Cruikshank, a graduate of Carnegie Institute of Technology was associated with Pittsburgh Coke and Chemical Corp. and Columbia-Southern Chemical Corp. before serving as process engineer in the film development section of AviSun's research and development department.

William C. Mertz has been promoted to the position of Project Engineer for film development at the Dobeckum Co., a division of the Dow Chemical Co. A chemical engineering graduate of Purdue University, Mr. Mertz started out as a research chemist in 1953.

J. Harry Du Bois, formerly Board Chairman of Tech-Art Plastics Co., Morristown, N. J., becomes Vice-President of the company which was recently acquired by Pratt, Read & Co., Inc. as a wholly owned subsidiary. Mr. Du Bois has 32 years of experience covering all phases of the plastics molding field holding top management positions with The General Electric Co., Shaw Insulator Co., Plax Corp., Mycalex Corp. of America and Synthetic Mica Co. A former national president of SPE, he is Engineering Editor for "Plastics World."

John Badonsky, Chief Engineer of Waldron-Hartig Division, Midland-Ross Corp., died recently. Mr. Badonsky, a well known authority in the extrusion field, was with Hartig for three years. He is survived by his widow and four children.

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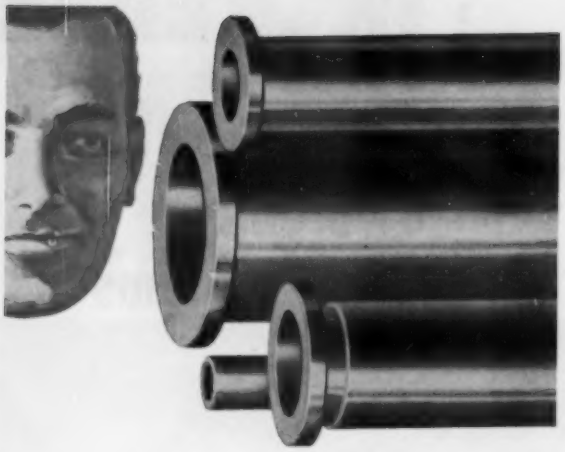
Lower compression loads! "Genetron"-blown foams are softer . . . make perfect upholstering material in furniture, auto seats, bedding!

Our technical service will help you with "Genetron" applications right in your own plant. Write today for more information about this service.

Other major components of the urethane foam system produced by Allied Chemical: polyethers and Nacconate® diisocyanates by National Aniline Division; resins by Plastics Division.

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.



only **Xaloy**

bimetallic cylinders can give you 25 years of proof!

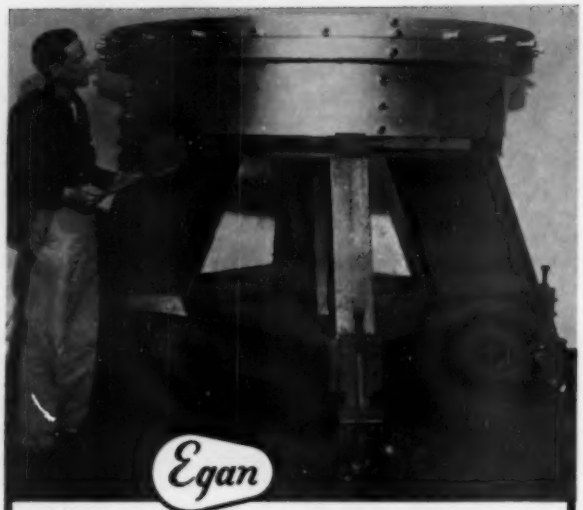
For 25 years Xaloy extruder cylinders have ideally answered the corrosion and abrasion resistance requirements of the plastics and rubber industries. These integrally-bonded, mirror-smooth Xaloy linings are centrifugally-cast to provide the world's most advanced extrusion cylinders. We invite your inquiry concerning your individual specifications.

Xaloy... the original equipment on all leading extruders

Xaloy... the logical replacement for longest life

WRITE FOR XALOY DATA GUIDE

INDUSTRIAL RESEARCH LABORATORIES
Division of Honolulu Oil Corp.
961 East Slauson Ave.
Los Angeles 11, Calif.



Egan

BLOWN TUBING DIES UP TO 80" DIAMETER

Shown above is a 72" thin wall tubing die.

A complete line of Egan Extruders from 2" through 12" and Accessories are available . . . Write for Illustrated Material.

FRANK W. EGAN & COMPANY
SOMERVILLE, N. J.

About Members

(*Continued from page 1121*)

Miles Powell, Jr., has been appointed general sales manager, Chemplast, Inc. He was with DuPont for the last eleven years, holding key positions in the plastics division. Mr. Powell is a graduate in chemical engineering of the University of Delaware.

Hercules Powder Co., Polymers Department, has announced the appointments of **Charles A. Borton,** district manager, Cleveland; **John L. McKeen,** Chicago; **Paul J. Metzger,** West Coast; **Daniel G. Welsh,** Cincinnati and **Robert R. Stover,** New York.

Frederic M. Rea, Publisher, "Western Plastics" Magazine, serves as Vice Chairman, SPI Western Section, for the coming year.

Michael Pisetzner has been promoted to the position of general manager, Electro-Technical Products Division, Sun Chemical Corp. A graduate of Cooper Union Institute of Technology with a B.S. in chemical engineering, Mr. Pisetzner is a licensed Professional Engineer in New York State, and has studied at Columbia University, Brooklyn Polytechnical Institute, Long Island University and N.Y.U. He has been in the chemical field since 1935.

So that you can get the information you want in the shortest possible time, we suggest you write directly to the company address listed at the end of each new product item.

New Materials and Equipment

MATERIALS AND APPLICATIONS

Pearly Vinyl Fabrics Without costly pearl pigments, "Qwikmil" soft metallic colors, latest in pigments for calendered vinyl, yield lustrous fabrics in one step. Its addition to the clear calendering compound, colors to suit the customer are reported possible. *Dept. SPE,* **Claremont Pigment Dispersion Corp., 39 Powerhouse Rd., Roslyn Heights, L. I.**

Transporting Beer A plastic beer case has been developed that is reputed to give four times as much service as the conventional fiberboard container. Made of a high density polyethylene by the Plastics Division of the Koppers Co., it is being produced by the Panelyte Div., St. Regis Paper Co. Information, *Dept. SPE,* **Plastics Div., Koppers Co., Inc., Koppers Bldg., Pittsburgh 19, Pa.**

Resin in Powdered Form A monomer-free, unsaturated isophthalic polyester resin, in powdered form, is now available. C. Rezyn 2, as it has been designated, is packaged in 50-pound multiwall kraft paper bags, saving shipping and storing costs, according to the manufacturer. It is said to give very fast solution in styrene monomer to produce an isophthalic polyester resin with exceptional adhesion to fiberglass reinforcement. *Dept. SPE,* **Commercial Resins Corp., 1250 W. 7 St., St. Paul 2, Minn.**

New Membrane Line Development of a new line of ion-exchange perm-selective membranes described as specially treated natural or synthetic polymers in film or mat form, with properties making them useful as battery separators and in dialysis, filtration and other separation processes, has been made known. Major users include manufacturers of alkaline batteries; sugar and petroleum and metal refineries; and concerns engaged in water treatment and desalination projects. *Dept. SPE,* **Radiation Applications Inc., L.I.C., New York.**

Fiber Glass Storage Tank A cylindrical liquid storage tank using chopped glass fibers and polyester resin to form a one piece cylinder is under development by a newly organized company. Testing indicates the possibility that the tanks can provide exceptionally high strength and unusual corrosion resistance. Potential users: sour crude petroleum market, chemical process industries, and agricultural market. *Dept. SPE,* **U.S. Fiber Glass Industries, Inc., P.O. Box 363, Vincennes, Ind.**

High Speed Coating Development of a polyethylene resin which can be extruded to give telephone and control cables smooth insulation coatings at high speeds such as 4,000 feet per minute, has been announced by du Pont. Known as "Alathon" 3530 polyethylene resin, it is said to demonstrate fine aging properties, toughness, flexibility at low temperatures, and moisture resistance. It can be colored, and is available in commercial quantities. *Dept. SPE,* **Polyolefins Div., Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.**

New Ester-Type Plasticizer A material said to combine the best feature of both monomeric and polymeric plasticizers, RC Plasticizer TM, a tri-ester of trimellitic anhydride, has been developed. The relatively high molecular weight of this primary plasticizer is reputed to assure low volatility while its three ester groups result in excellent solvation and compatibility. It is recommended by the manufacturer for all quality uses requiring a high degree of permanence as well as ease of processing. *Dept. SPE,* **Rubber Corporation of America, New South Rd., Hicksville, N. Y.**

New Resins in 0.962 Density Range. The availability of three new types of high-density polyethylene resins offering new properties for all injection-molded polyethylene articles and for film and paper coatings has been made known. In effect, the new resins which are in the 0.962 density range, make possible the commercial molding of polyethylene objects which are adequately stiff in thin sections without their becoming brittle or subject to flex-cracking. *Dept. SPE,* **Hercules Powder Co., Hercules Tower, 910 Market St., Wilmington 99, Del.**

All-Plastic Insulation Use of a "plastic sandwich" insulating panel for the interior walls of a revolutionary refrigerated freight car accounts for its ability to maintain any temperature from −10°F to +70°F. Dylite expandable polystyrene, a plastic produced by Koppers Company, Inc. and the protective qualities of Cycolac plastic, a product of the Marbon Division of Borg-Warner Corp. are the materials used for the new type panels that insulate the Pacific Fruit Express railroad cars which carry fruit and produce from coast to coast. A special feature of construction permits the Dylite-Cycolac panels to be fastened directly to the steel sides of the car. Information from *Dept. SPE,* **Koppers Co., Inc., 3450 Wilshire Blvd., Los Angeles, Calif. or Marbon Chemical Div., Borg Warner Corp., Washington, W. Va.**

Disposable Cartons A disposable carton with a pliable film liner for the shipment of liquid or semi-liquid products has been developed along with a new machine designed to fill and close the new container. *Dept. SPE,* **Bemis Bro. Bag Co., Physical Research Dept., 325-27 Ave. N.E., Minneapolis 18, Minn.**

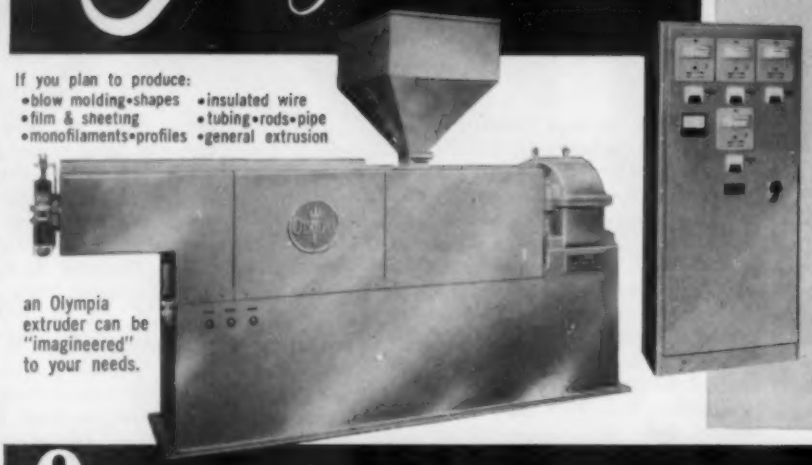
The "Old" and The "New"

OLYMPIA

"Imagineered"

EXTRUDERS

If you plan to produce:
•blow molding•shapes •insulated wire
•film & sheeting •tubing•rods•pipe
•monofilaments•profiles •general extrusion



an Olympia extruder can be "imagineered" to your needs.

ARE DESIGNED TO INTERPRET EXACT CUSTOMER REQUIREMENTS.

Because no one application is exactly the same in its requirements, no one ever buys a standard extruder. Each must be customized to a certain degree by varying the screw, h. p., heaters, cooling systems, control panels, etc. Determining the right combination for your application takes "imagineering" that can only come from years of designing and building experience and an extra measure of creativity. Olympia has 20 years of extruder design and building experience and a host of satisfied customers who can testify to the high degree of creativity employed to solve their specific problem. Why not put Olympia to work on your problem. Basic specifications for extruder sizes ranging from 1½ to 6 with L/D ratios from 20:1 to 24:1.

OLYMPIA TOOL AND MACHINE CO.
119-121 DELANCY ST. • NEWARK 5, N. J. • MArket 2-4219

OLYMPIA

EQUIPMENT

New 2-Oz. Injection Molding Machine Fully hydraulic, fully automatic, a new 2-oz injection molding machine is being produced said to be the fastest ever built. With a plasticizing capacity of 50 pounds/hour, maximum daylight of 18", clamping pressure of 56½ tons, and maximum mold plate size of 12" x 15" horizontal and 8" x 19" vertical, it has a dry run capacity of 20 shots/min. *Dept. SPE,* **DeMattia Machine & Tool Co., Allwood, Clifton, N.J.**

Vertical Saw, Budget-Priced Designed specifically for the smaller foam fabricator and distributor, a new vertical saw foam fabricating machine is said to provide for complete foam fabricating operation. *Dept. SPE,* **FEMCO, 1734 Front St., Cuyahoga Falls, Ohio.**

Introducing New Hot Stamping Machine Model EA-10 air operated hot stamping machine with rotary turntable feed said to stamp on areas up to 6" x 6" will be introduced and exhibited at the Packaging Machinery Manufacturers Institute Show in Detroit this November. Information, *Dept. SPE,* **Apex Machine Co., 14-13 118 St., College Point 56, N. Y.**

"Proportionator" Developed Accurate proportioning of color concentrate granules with uncolored material is said to be possible with a new "Proportionator". The new type of metering device is said to permit infinite ratios of concentrate to be proportioned accurately. Granular scrap and virgin materials demanding very accurate mixtures are reported handled as well. *Dept. SPE,* **Thoreson-McCosh, Inc., 18208 W. McNichols Rd., Detroit 19, Mich.**

Compact Screw Plasticizer A six-ounce screw plasticizer injection molding machine, said to be the first of its size made in America has been introduced. With a plasticizing capacity of 60 pounds/hr., it processes vinyls and other thermoplastic materials, *Dept. SPE,* **Standard Tool Co., Leominster, Mass.**

Extruder Measuring Head Introduced Designed to measure and record torque required to process polymers under a wide range of screw speed rates and barrel zone temperatures, a ¾" extruder measuring head has been introduced to supplement the others made by the manufacturer to measure factors affecting the processability of all polymers, plastics and rubber. The new extruder head is reputed to add to the machine the ability to measure polymer extrusion rates, extrudate surface conditions and the effect of lubricants. *Dept. SPE,* **C. W. Brabender Instruments, Inc., South Hackensack, N. J.**

Fast Mold Start-ups When mold circulators are not used, a new mold starter for use on injection molds is reported to increase press production by as much as half an hour per day where one or two shift molding is done. *Dept. SPE,* **Injection Molders Supply Co., Inc. 17601 So. Miles Rd., Cleveland 28, Ohio.**

New Molding Machines Ten new extruder-type injection molding machine models, including five single-stage machines and five two-stage preplasticizers have been introduced. The IX model single-stage machines, equipped with hydraulic clamps ranging from 200 to 1000 tons, with material capacities from 15-oz. to 40-oz. injected per cycle, is recommended for heat-sensitive materials. The PX models, with material capacities from 28-oz. to 50-oz. injected per cycle, are normally used for high quality, precision molding. *Dept. SPE,* **Hydraulic Press Mfg. Co., Div., Koehring Co., Mt. Gilead, Ohio.**

(*Continued on page 1129*)

RCI POLYLITE Plastic Concrete Forms Cut Building Costs!

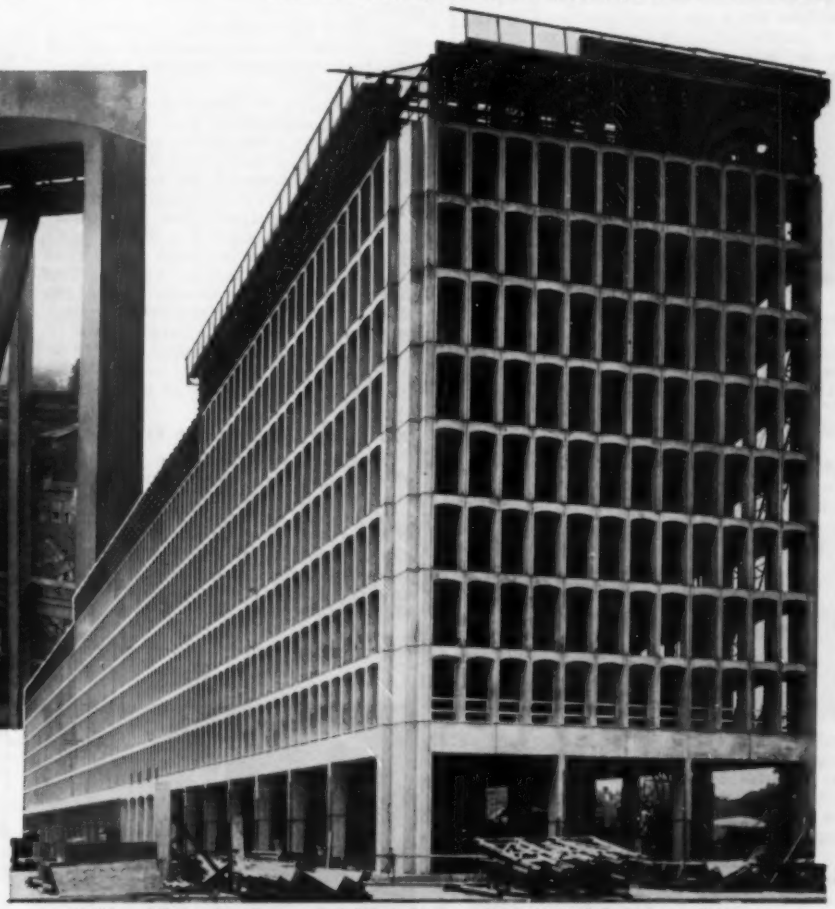
• "Reinforced plastic concrete forms made with RCI's POLYLITE polyester resin were responsible for cutting form costs by one-third in this Webb and Knapp apartment project," states Myron Austin, design engineer for Engineered Concrete Form Corporation, Chicago.

Al Schreck, carpenter superintendent for James McHugh Construction Co., Chicago, found these important advantages in reinforced plastic forms:

- They can be adapted to virtually any shape.
- They have greater strength to withstand the impact stresses of cement pours; flexural strength is about 30,000 psi.
- Light in weight, about half that of conventional forms, they can be handled and erected more economically.
- Highly resistant to abrasion, they can be used over and over again.
- Low expansion/contraction properties of reinforced plastic forms, when exposed to heat and cold, provide a high degree of dimensional accuracy in the cured concrete.
- The smooth plastic surface of the forms provide the trowelled-like finish of a skilled concrete artisan, without extra cost.

This is only one example of how plastics are improving on old techniques. If you have an application which might be simplified or improved by the use of reinforced polyester, it will pay you to call on RCI.

Part of the Webb and Knapp apartment project in Chicago which contains 4,500 arched windows poured in POLYLITE plastic forms; and close-up of one of the POLYLITE forms. With proper handling, forms can be used 50 to 100 times.



Webb and Knapp, Developer — I. M. Pei, Architects — James McHugh Construction Company, Concrete Subcontractor — Engineered Concrete Form Corporation, Form Manufacturer

Creative Chemistry ... Your Partner in Progress

RCI

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol • Hydrochloric Acid
Formaldehyde • Phthalic Anhydride • Maleic Anhydride • Ortho-Phenylphenol • Sodium Sulfite
Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate • Sulfuric Acid • Methanol

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

U.S.I. POLYETHYLENE NEWS

A digest of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

Packaging Notes

Polyethylene pour spout comes in sizes to fit quart and gallon paint cans. Snaps on and off in seconds and is reusable. Keeps paint out of lid groove. Puts an end to messy dripping. Available imprinted with advertising message.

Square-bottom and 3-D style polyethylene bags are being produced by a N. Y. converter from black and natural film in "any size . . . all gauges." A

3-D style polyethylene bag can stand unsupported for easy filling.

specialty is large, tailored shrouds and covers for domestic and military protective packaging. The largest to date: 450" x 96" x 168". Electronic seals are said to exceed strength of base material.

Bottom-seal attachment is now available for side weld bag machines made by a leading company. With it, bottom-

seal polyethylene bags 8" wide x 16" long can be produced at a rate of 200 per minute. According to the manufacturer, production speeds on large bags are also excellent, since bags up to 65" long may be made with a single stroke.

Tote barrel of molded polyethylene construction has sturdy wire handles and masonite reinforced bottom. It's dent-proof, water-proof and rust-proof, yet light in weight — an ideal multi-purpose container. Available in various sizes, including 25 and 45 gallons.

Polyethylene-Metal Construction Key to Lower-Priced, Higher-Quality Toys

Comparable All-Metal Items Take Longer to Make . . . Retail for More

In the highly competitive toy industry, a slightly lower retail price can be a critical factor—the difference between a good seller and a "shelf-sitter." And therein lies the primary reason why polyethylene is being incorporated in traditionally all-metal toys.

It lowers production costs, and—when used functionally — adds quality. The ultimate result: part-polyethylene, part-metal toys can be marketed at a price lower than all-metal items of similar quality.

Consider the experience of a company which produces nationally-marketed miniature cars, trucks, trailers, vans and boats.

The decision to combine the advantages of polyethylene and metal in a new line was made about a year ago. Since, sales and production figures have verified the success of the venture. According to the firm's purchasing agent:

"Combining polyethylene and metal has enabled us to market a higher quality product within the price range that encompasses our logical market. The polyethylene-metal toys retail for $1.00, which we feel is the right price for this type and size of toy. All-metal toys of this kind would have to retail at $1.19 or $1.29, making it necessary to fight sales resistance that doesn't exist at the $1.00 level."

Secondary Operations Eliminated

On the production line, the polyethylene-metal concept has worked out smoothly and efficiently. Manufacture culminates at the injection molding machines (each of which produces up to 200 polyethylene parts per minute depending on size and complexity), where molding machine attendants join the polyethylene parts with previously-cut metal parts made from zinc castings. Since there's little need to finish, scrape or trim the polyethylene components, secondary operations are virtually eliminated.

Assembly consists simply of securing the plastic part to its metal base by means of slots or undercuts. Wheels of injection-molded black polyethylene are then quickly affixed, and the toy is ready for packaging.

Moving van is typical of part-polyethylene, part-metal toys currently available. Wheels are made from U.S.I.'s PETROTHENE 597 resin, other plastic components from PETROTHENE 241. Chassis and cab are metal. Lower photo shows construction details.

U.S.I.'s Role

U.S.I., as the polyethylene resin supplier, played an important part in the successful development of these toys. U.S.I. engineers were able to assist in establishing optimum equipment operating conditions, such as mold cycle times, and in making suggestions on materials.

The resin selected had to be absolutely uniform and have good strength, stiffness, gloss, colorant dispersion, and shrink and warp resistance. PETROTHENE 241 met these requirements and is being used for all parts but the wheels, which are made from PETROTHENE 597.

His 'n Hers

New from France . . . a nubbly textured polyethylene rain hat designed to be worn by either a man or woman. It comes in a colorful, pocket-sized pouch. Can be turned into a cloche, or into one of a choice of men's styles, in seconds.

Available clear or in opaque colors, the hats are vacuum-formed from PETROTHENE 239-27 in Neuilly-sur-Seine. The U.S.I. resin was selected because it imparts stiffness and gloss, while providing optimum processing properties.

Employment & Service Guide

POSITIONS OPEN

PLANT MANAGER

Position open in modern progressive injection molding plant located in Southern Connecticut. Applicants must be thoroughly experienced in molding techniques, molds and press operation to intelligently direct and supervise production phases of quality items. Mold repair and press maintenance. Salary open. Reply to Box No. 298, SPE JOURNAL.

PLASTIC EXTRUSION EXPERT

Wanted by large custom manufacturer. Minimum 10 years experience with diversified materials required. Salary commensurate with ability. Box SPEJ 1152, 125 W. 41 St., New York 36, N.Y.

PLANT MANAGER, medium size established Custom, Compression and Transfer Molder offers excellent opportunity to right man. Must have supervisory background, knowledge of thermosetting materials, engineering, maintenance and production. Office and plant responsibilities. Send resume and salary requirements. Accurate Molding Co., Inc., 35-20 48th Avenue, Long Island City 1, N. Y.

PLASTICS ENGINEER

This well known manufacturing concern offers a fine opportunity for a BS in Chemical Engineering with 3 to 6 years experience in the field of thermoplastic testing. The individual selected for this position will head a research group which specializes in the testing of plastic materials particularly in the areas of injection and compression molding and extrusion. He must be capable of developing new testing techniques. To arrange confidential interview submit resume including salary requirements to:

Personnel Manager

J. T. Baker Chemical Company

Phillipsburg,

New Jersey

An Equal Opportunity Employer

SENIOR PLASTICS ENGINEER

To develop, plan and supervise long range research programs to explore properties of new materials and develop materials that will meet specific design requirements.

Current problems include filled plastics (both thermoplastics and thermosetting), foams, elastomers, adhesives, coatings, and laminates. Typical properties specified are strength, density and density uniformity, thermal expansion, thermal and electrical conductivities, thermal-shock resistance and load-deflection characteristics.

POSITION REQUIREMENTS:

Degree in Chemistry or Chemical Engineering (Ph.D. preferred).

Thorough knowledge of the physics and chemistry of high polymers.

Broad experience in formulating a wide variety of plastics.

U.S. Citizenship required

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Please send your confidential resume to:
Keith E. Moseley
Personnel Department

LAWRENCE RADIATION LABORATORY
University of California
P.O. Box 808X
Livermore, California
(One hour from downtown San Francisco)

CLASSIFIED INFORMATION AND RATES

SPE members in good standing are entitled to a total of three no-charge "Positions Wanted" advertisements within any 12-month period, each ad (not to exceed 50 words) should include training, experience, location desired; headline (not to exceed 3 words) must state job description. Additional words will be charged @ 25¢. *Do not* submit resumes: none are kept on file.

Last day for inserting all classified ads is the first day of the month preceding date of publication, except for display size ads which close on the 15th of month preceding issue date.

"Positions Open" and "Positions Wanted" —$12.50 per column inch, 2¼ inches wide. (35 characters per line; 7 lines per inch). Minimum charge: $12.50. Pre-publication contact, known as the "Availability File"—$5 service charge on "Positions Open"; no charge to SPE members. *See adjacent box for a description of how it works.* "Products and Services" and "Business Opportunities" —$20.00 per inch. Minimum charge: $20.00.

All ads include one bold face caption line. Additional caption lines @ $2.50 extra per line. Boxed ads (4-sided rule)—$3.00 extra. Agency commission allowed *only* on ads 5 inches or more in depth. Display ads of 1/16 page or more are charged at regular advertising space rates. No ¼ page or vertical ½ page ads published within Employment Service Guide section. Typesetting (non-commissionable) will be charged at cost.

HOW OUR "AVAILABILITY FILE" WORKS

If you are a company, or an SPE member who will be advertising in SPE JOURNAL, you can receive copies of those classified ads of potential interest to you *before* they are actually published in the Journal, provided that these advertisers have also indicated their interest in the same procedure. This pre-publication contact is what we call our "Availability File". All you have to do to participate is to sign the return postcard we send you upon receipt of your advertising insertion. When your card is returned, the ads are sent to you as they come in, up to publication date.

PLASTICS DEVELOPMENT ENGINEER

We have an attractive opening in our New Product Development Dept. for an engineer or chemist to work on fabrication techniques for new thermoplastics. B.S. minimum, 3-10 years broad experience in fabrication of plastics, especially extrusion. Send resume in confidence to Dr. David M. Clark, Director of Technical Recruiting, W. R. Grace & Co., Research Division, Clarksville, Md.

PLASTIC PIPE PRODUCT MANAGER

A leading New England company has an opening for a man with sales experience in plastics, preferably one with an engineering background, to set up a new sales and technical service function aiming toward nationwide coverage for plastic pipe.

Immediate emphasis on training present sales force and working on technical service procedures. Field application and sales experience in pipe essential. Extensive traveling expected.

Please send resume including salary requirements to: Box No. 306, SPE Journal.

ASSISTANT SALES MANAGER FOR D-M-E

D-M-E has a unique opportunity for right man to assist Sales Manager at home office in Detroit and in the field. Prefer man with proven sales ability and mechanical or metallurgical degree. Experience in design and construction of plastic molds & die cast dies desirable. Must live in Detroit area and be available to travel. Excellent opportunity to grow with nation's leading supplier of Standard Mold Bases and moldmakers' supplies. Send recent photo and complete resume to:

L. J. Morrison—D-M-E Corp.,
6686 E. McNichols Rd., Detroit (12)

EXTRUSION ENGINEER

Chemist, or Chemical Engineer with compounding and process experience in vinyl extrusion. Film experience and knowledge of testing procedures desirable. Opportunity for growth in an aggressive organization. Send complete resume to:

R. A. Greenleaf,
Development Manager
Borden Chemical Company
Thermoplastics Division
1 Clark Street
North Andover, Mass.

Thermoplastics Engineers

—Technical Service—

B.S. Mechanical or Chemical Engineering with 2-8 years experience in thermoplastics processing (extrusion, injection molding) and/or applications to perform technical service by assisting customers in molding, extruding, and applying thermoplastics. To be located at technical service laboratory in either Morrisown, N. J. or Edgewater, N. J. Liberal company benefits.

Please send resume and salary requirement to Mr. T. R. von Toerne, Research Laboratory.

PLASTICS DIVISION

Allied Chemical

1 River Road — Edgewater, New Jersey

TOOL DESIGNER

Growth opportunity with well established proprietary molder for man with heavy experience in plastic injection mold design. Knowledge of modern molding machines desirable. Send resume, include salary required to Sterling Plastics Co., 1140 Commerce Ave., Union, N. J.

GENERAL SALES MANAGER

Major manufacturer of plastic processing machinery has openings for top level manager. Experience in plastics industry and machinery sales required. Responsible for directing national sales organization. Salary, commission, and expenses. Write advising present position, salary level, and experience. Box No. 275, SPE Journal.

POSITIONS WANTED

R & D ENGINEER

Chemical engineer, seven years diversified experience in research, development and sales service of thermoplastics materials, desires to utilize talents with progressive organization. Alert, aggressive, willing to relocate. Box No. 269, SPE JOURNAL.

PRODUCT MANAGER OR MARKET DEVELOPMENT

Proven ability in sales and in market research and development in organic chemicals, solvents, thermosets and thermoplastics. Proficient in promoting to corporate top management or selling production operator. A combination of major corporation know-how and small company self-reliance. B.S. in Chemical Engineering. Box No. 256, SPE JOURNAL.

SALES ENGINEER

B.S.M.E. Past eight years spent in technical service, sales and application engineering associated with plastics and plastics processing equipment. Solid background in screw extrusion. Total of twenty years industrial and supervisory experience. Age forty two. Prefer some traveling from Phila. area. Box 311, SPE Journal.

PLASTICS ENGINEER

Age 34, married, 12 years extrusion experience in sheet, shape, pipe, tube, rods, compounding, laminating, supervision, production, maintenance, trouble shooting, tech sales help, design, equipment layout. Detroit or vicinity location preferred. Will relocate. Some travel. No degrees. Resume on request. Box No. 297, SPE JOURNAL.

DEVELOPMENT MANAGER — B.S. Chemist with 12 yrs. experience in resin development from research stages through evaluation and testing to commercial production, exploitation and service requirements desires California location. Direct experience with all major classes of condensation polymers and some addition polymers. Responsibility and advancement opportunity desired. Box No. 299, SPE Journal.

ENGINEERING EXECUTIVE

6 years Treasurer & Chief Engineer for Injection Molder/Vacuum Former. Duties: Purchasing, Estimating, R&D, Mold & Equipment Design, Customer Contact, Plant Office & Sales Management. Age 34. Prefer Midwest. Box No. 302, SPE Journal.

MANAGER PRODUCT DEVELOPMENT

Ch. Eng. 12 years broad experience. Process and product development thermoplastics and thermosets, coatings, lamination, extrusion, dielectric systems, varnishes, molding. Has proven ability and ingenuity with accomplishments. Tech. papers, patents. Desires challenging position with growth potential. Age 38. Sal. min. $14,000. Box No. 301, SPE JOURNAL.

INJECTION MOLDING

Knows business from coveralls to white shirt. Unusual combination of technical skill and business management. Can operate in plant or out. Both desk and factory man. Can relieve owner or president of day to day operational duties. Can train personnel, institute systems and organization either in existing or projected plant. Box No. 214, SPE Journal.

PLASTIC MOLD ENGINEER

Twenty years experience in injection molds. From development of item to drawing board, mold cost, to tool room supervision. Testing and getting mold into production. Coordinating all phases of manufacturing and procurement. Broad versatile background in toys, housewares and industrial fields. Eastern area preferred. Box No. 300, SPE Journal.

PRODUCT AND TOOL ENGINEER

15 years experience in reinforced plastics and injection molding. Supervision of carving, pattern, casting, and tool room. Specializing in low cost cast alloy injection molds. Design engineering details, drawings, preparation of molds and piece price quotations, custom or proprietary items. Sales engineering experience on custom molding. Will relocate. Resume upon request. Box No. 277. SPE Journal.

MANUFACTURING MANAGEMENT

Over ten years experience in all phases of manufacturing management in plastics includes supervision, controls, scheduling and administration. M.I.T. degrees in chemistry and business. Achievements include cost reductions, productivity increases, new products. Desire challenging position with growth based on performance. Relocate. Box No. 304. SPE Journal.

TOP FLIGHT IDEA CHEMIST

B.S., offers 20 years of proven ability to innovate. Coatings, plastics, resins, paper saturation, adhesives. Tough problems a specialty. Box No. 276, SPE Journal

BLOW MOLDING CONSULTANT

B.S. in M.E., B.S. in B.A., M.B.A., 35 years old, 15 years experience. Will set up a blow molding operation, recommend machinery, install it, design and supply utilities, design and procure molds and finishing equipment, train personnel. References supplied. Write to Box No. 303, SPE Journal.

ENGINEER

Experienced in the development, design and production of foamed polystyrene products. Will relocate. Resume on request. Box No. 305, SPE Journal.

PRODUCTS & SERVICES

INJECTION • BLOWING
COMPRESSION • TRANSFERS

MOLDS

Quick Delivery, Cheapest Prices

DANISH MOULD ENGINEERING

Osterbrogade 54D

phone **TRIA 3100** • *cable* **DANIMOLD**
COPENHAGEN, DENMARK

MOLDS

Injection compression transfer, quality molds, good delivery, competitive prices. Tested before delivery, laid down in your plant. Steel Dies & Moulds Ltd., 43 Raleigh Ave., Toronto, Canada. PH. AM 1-7092

MANUFACTURERS' LITERATURE

(Continued from page 1124)

Electric Controls for the Plastics Industry A six-page folder is now available defining the use of starters, contractors, enclosures, push buttons and safety switches for all types of blow molding and induction heated extruding machinery. Write *Dept. SPE,* **Arrow-Hart and Hegemen Electric Company, 103 Hawthorn Street, Hartford, Connecticut.**

Reinforced Plastics A new "state of the art" brochure, Bulletin No. 300-61 is available with special attention given to high temperature plastics for space applications. Low and high pressure press molding, high pressure autoclave, vacuum bag and filament wound structures are reviewed. Write *Dept. SPE,* **Swedlow Inc., 6986 Bandini Nfld., Los Angeles 22, California.**

Radiation of Fluorinated Polymers Reprints of the paper, "The Predominant Reaction of Some Fluorinated Polymers to Ionizing Radiation" are available. This paper was originally presented by Robert Timmerman in January, 1961 to the 1961 ANTEC in Washington. Write *Dept. SPE,* **Radiation Dynamics, Inc., Westbury, Conn.**

SMA Resins Texas Butadiene & Chemical Corporation has issued an 8-page brochure describing the properties of a new series of styrene-maleic anhydride copolymers. Probable uses are water based paints, finishing leathers, adhesives, floor polishes etc. Write: *Dept. SPE,* **Polychemicals Department, Texas Butadiene and Chemical Corporation, 529 Fifth Ave., New York 17, N. Y.**

Polyethylene Gycol Data A 65-page booklet describing the properties and applications of PEG has been published by Union Carbide. Included is information on specifications, testing, storage, handling and literature references. *Dept. SPE,* **Union Carbide Chemicals Co., Div., Union Carbide Corp., 270 Park Ave., N. Y. 17, N. Y.**

Guide for Molders "Fiberglas Materials for Matched-Die Molding Selection Guide" contains descriptions of the four basic Fiberglas non-woven reinforcements, and overlay and surfacing mats designed for use with the basic reinforcements for improved surface finish 16 illustrated pages, *Dept. SPE,* **Publ. No. 5-PL-1851, Dept. 1833, Owens-Corning Fiberglas Corp., 717 Fifth Ave., N.Y. 22, N.Y.**

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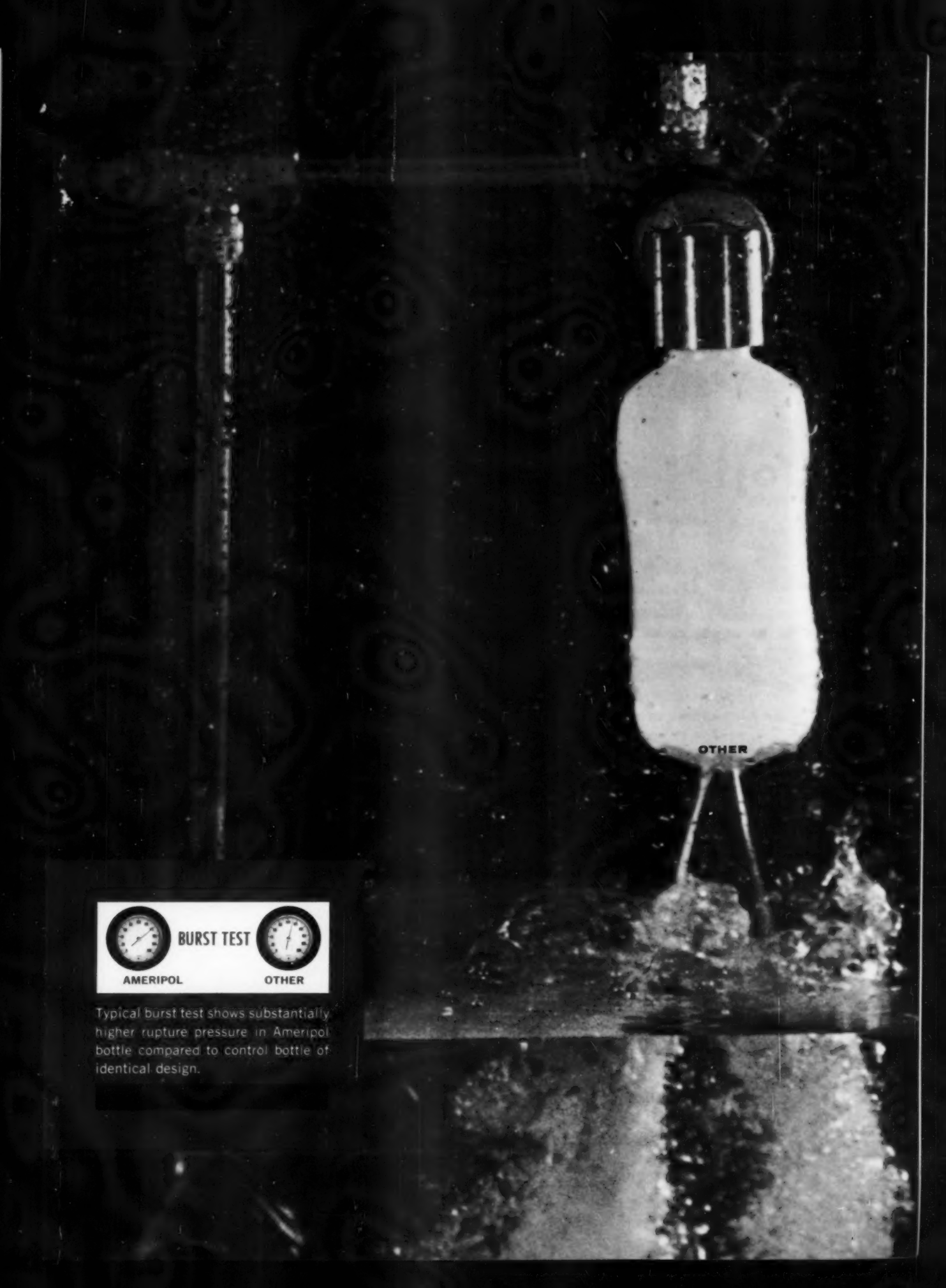

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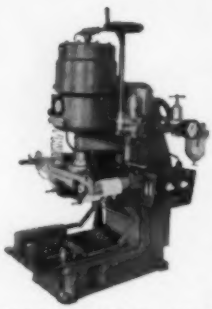

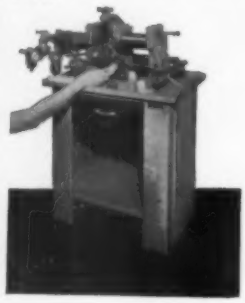

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Archer-Daniels-Midland Co. 1053
Argus Chemical Corp. 1082
Barber-Colman Co.,
Wheelco Industrial Instruments Div. ..... Cover 3
B. I. P. Engineering Ltd. 1080
The Black-Clawson Co. 1113
Cadet Chemical Corp. 1132
Celanese Corp. of America—Chemicals 1111, 1112
Columbian Carbon Co 1063
Curtiss-Wright Corp., Princeton Div. 1048
Davis-Standard 1068
D-M-E Corp. 1043
Dow Corning Corp. ..... Cover 4
E. I. Du Pont de Nemours Co.,
Polychemicals Div. 1042
Durez Plastics Div., Hooker Chemical Co. 1075
Frank W. Egan & Co. 1122
Enjay Chemical Co., Div. Humble Oil & Refining
Co. Chemicals 1038
Polypropylene 1114
General Chemical Div., Allied Chemical Corp. 1120, 1121
General Dyestuff Corp.—Collway Div. 1051
Gering Plastics, Inc.,
Div. Studebaker-Packard Corp. 1069
B. F. Goodrich Chemical Co. 1035
Goodrich-Gulf Chemicals, Inc. 1130, 1131
W. R. Grace & Co., Polymer Chemicals Div. 1046
Harshaw Chemical Co., Kentucky Color Div. 1058
Hooker Chemical Co., Durez Plastics Div. 1075
Improved Machinery Inc. 1062
Industrial Research Laboratories 1122
Injection Molders Supply Co. 1078
Kentucky Color Div., Harshaw Chemical Co. 1058
Lucidol Div., Wallace & Tiernan, Inc. 1108
Metal & Thermit Corp. 1105
Monsanto Chemical Co., Organic Chemicals Div. 1050
National Aniline Div., Allied Chemical Corp. 1109
National Distillers & Chemical Corp.,
U. S. Industrial Chemicals Co. Div. 1126
National Lead Co. 1047
Nopco Chemical Co. 1056
Olympia Tool & Machine Co. 1124
Package Machinery Co., Reed-Prentice Div. 1039
Chas. Pfizer & Co.—Industrial 1117
Phillips Chemical Co. 1081
Pittsburgh Chemical Co.,
Industrial Chemicals Div. 1044
Plastic Molders Supply Co. 1119
Plastics Engineering Co. 1104
Prodex Corp. 1064
Reichhold Chemicals, Inc.—Plastics 1125
Reed-Prentice Div., Package Machinery Co. 1039
Rohm & Haas Co.—Plastics 1040
John Royle & Sons 1052
Sterling, Inc. 1045
Studebaker-Packard Corp.,
Gering Plastics Inc., Div. 1069
Swift & Co., Chemicals for Industry Dept. 1106
Union Carbide Plastics Co.,
Div. Union Carbide Corp. 1076, 1077
U. S. Industrial Chemicals Co.,
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Welding Engineers, Inc. ..... Cover 2
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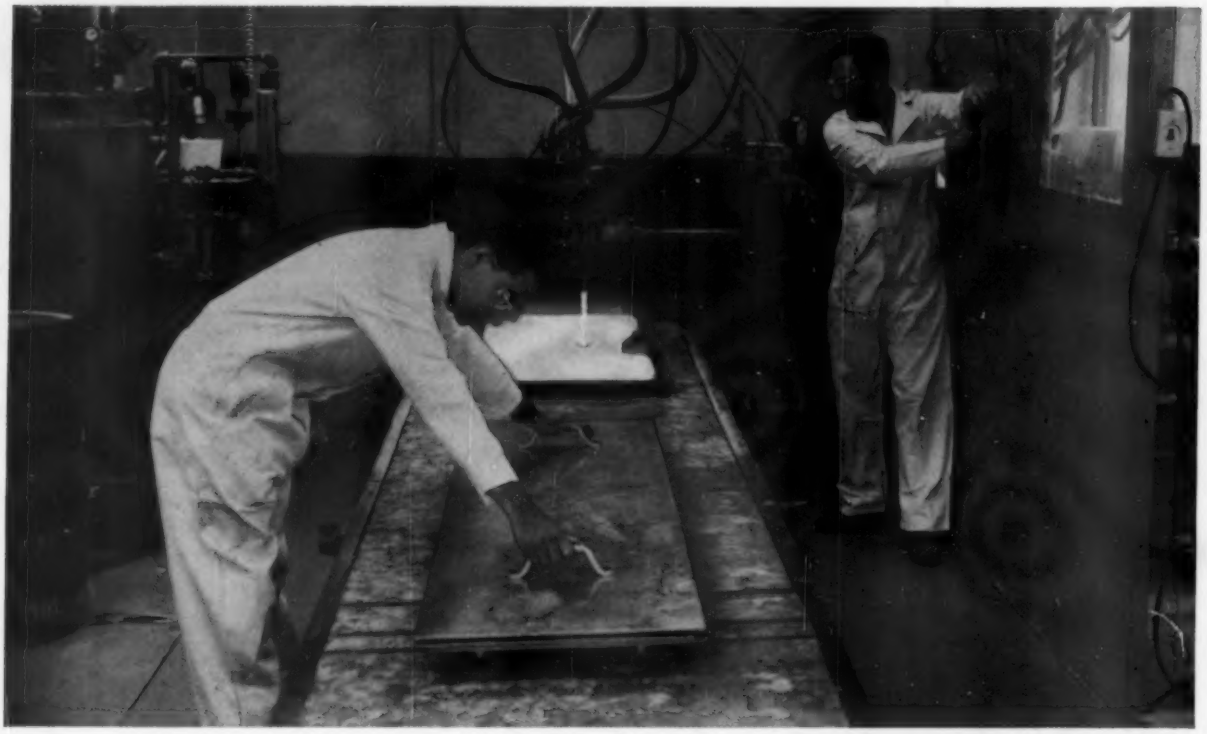

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